THE CONCEPT OF TIME

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THE CONCEPT OF TIME

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THE UNIVERSITY OF CHICAGO PRESS
CHICAGO · ILLINOIS

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TO MY MOTHER AND FATHER

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PREFACE

In stopping for a moment as one approaches the end of a comparatively long piece of work, one is impressed anew with the mysterious quality of our experience to which we have given the name "time." This is particularly impressive since time is the subject to which I have been devoting most of my thought. For change has affected both the aims and the subject matter; the concept of time also has assumed as many aspects as ever did any witch in a fairy tale, and there is little assurance that it has assumed any final form. In fact, its most impressive character is incompleteness, part of the indeterminateness which infests all our experience. Yet with all the changing forms of the concept, I have also been impressed with the cumulative character of this process which we call "time," that no form has been entirely lost. It is perhaps because of the effect of the time process that while the aim of this study is less extensive than that of my Doctor's dissertation from which it grew, there is a sketchy quality to even such analysis as is attempted and the synthesis is obviously incomplete. In so far as this is due to time itself, no apology is necessary.

Since I began this work, Professor Gunn's *The Problem of Time* has appeared; but his attention is directed less than mine to the early period, and our conclusions are very different. Because of this difference there is little overlapping of material; nor do I refer explicitly to his work in the course of this essay.

In looking back I am impressed with the multiplicity of my obligations—not all of which can possibly be mentioned. I am indebted to my former instructors at Mount Holyoke and Radcliffe, although no one of them is responsible for what I have written. It is evident, however, that on this subject my thought has been very much influenced by Professor Whitehead. To him I owe thanks not only for sharing his thoughts on time but also for his time, both in class and in conference. I also owe particular thanks to the late Professor Woods, in whose seminar I came to an interest in the subject of this thesis.

I wish also to acknowledge the courtesy accorded me at the Library of Congress, Widener Library, and Mount Holyoke College Library.

L. R. H.

Hood College
Frederick, Maryland
September, 1936

TABLE OF CONTENTS

PAGE

INTRODUCTION xi

I. PROBLEMS AND POINT OF VIEW 1

II. THE CONCEPT OF TIME IN GREEK AND MEDIEVAL PHILOSOPHY 19
  Early Definitions and Their Development . 19
  The Platonic Tradition 37
  The Aristotelian Tradition 55
  Summary of the Problems Raised by the Greeks and Their Medieval Successors . 75

III. THE MODERN PERIOD TO THE MIDDLE OF THE NINETEENTH CENTURY 81
  The Newtonian Concept 81
  The Early Philosophical Discussions . . 91
  The Psychological Approach 106
  The Kantian Definition and Its Development 112
  The Effect of the Theory of Evolution . . 120

IV. THE RECENT PAST AND PRESENT 125

V. THE PROBLEM OF THE REALITY OF TIME . . 197

VI. TOWARD AN ANALYSIS OF THE CONCEPT . . . 210

INDEX 233

INTRODUCTION

The following monograph is the result of a study begun as a Doctor's dissertation at Radcliffe College a number of years ago. The purpose of that dissertation, as stated, was "to reach as complete an analysis as possible of the concept of time." The aim at present is less extensive, to analyze some of the meanings that have been referred to under the heading of "time" and to attempt some synthesis of these. The similarity of this to the aim of Aristotle in the *Physica* iv. 10–14 might be pointed out. It involves finding out what men have meant by time as they have used the term in various sciences and in philosophy, by surveying the problems that have arisen in connection with this concept and the solutions that have been offered for these problems. The scientific and philosophical uses of the term have not been dealt with in an entirely separate way, although a distinction has been made throughout the study as far as is practicable considering the frequent overlapping of philosophy and the sciences.

It is one of the underlying assumptions of this essay that, while the discoveries of the natural sciences can never give us the answers to philosophical problems, they determine the method of dealing with these problems, suggest further answers, and change the meaning of old answers. This assumption receives some justification in a historical study of the concept of time.

The thesis was started partly because of the changes in meaning of time resulting from two recent physical theories—the theory of relativity and the quantum theory. To some extent these theories have determined the point of view and also what problems concerning time are to be discussed. Only such statement of the theories themselves has been attempted as is necessary to an understanding of this book. There are so many excellent reviews of them that it is not necessary to review them in detail or to evaluate their merits in their scientific aspects.

While these two theories to some extent set the problem, the intention is to avoid reading back into earlier writers ideas which are totally foreign to them. There has also been the endeavor to avoid robbing early writers of all significance by refusing to see the full implication of their remarks on a particular problem in the total setting of ideas then current. To appreciate or to state their meaning often involves rethinking their ideas in modern terms. The fact that the starting-point was two physical theories has not excluded from consideration the biological concepts which are of equal importance in determining our ideas of time. No analysis could be complete or valuable which neglected them. The relative importance of the two sciences has differed at different periods as far as their effect on the concept of time is concerned, although perhaps it might be said that at present their contributions are recognized more equally.

The historical study is of chief interest, but at the end there is an evaluation of the ideas discussed and a synthesis of them into a more or less coherent system. In the present transitional stage of both philosophy and the sciences, any synthesis is entirely tentative. On the other hand, an understanding of its history is important in any period in which the concept is being modified. This is essentially true at present of the concept of time. Perhaps the more so because it does not appear to be a simple concept but one which has two aspects, and any confusion of these is bound to lead to ambiguity. No attempt has been made to refer to everyone who has written about time. The attempt has been rather to indicate the general tendency of each period of thought, to note in each the contribution to this concept of the different sciences and of philosophy, and to refer to men representing different positions and characteristic of the various points of view.

CHAPTER I

PROBLEMS AND POINT OF VIEW

One key to the problem of this study lies in the recent developments of experimental physics. For one thing, the theory of relativity and its experimental verification demanded a radical change in the fundamental concepts of that science, among others a revision in the idea of space and in that of time. The experiments of physicists have led them to a theory of space-time which is analyzable neither into the Newtonian conception of space and time as absolutes having objective reality, nor into the relational concept proposed by Leibniz, nor into the Kantian interpretation of them which recognized their absolute character but considered them forms of perception. To put it briefly and therefore to some extent inaccurately, time is one aspect of the relatedness of events. The development of this new point of view concerning the natural world not only affected the ideas of space and time, with the resulting space-time, but has brought to the fore several problems concerning time itself.

What is the relation between time and motion? Between alternative time systems? What do we mean by simultaneous events? What is the relation between private and public time? With the possible exception of the second question, these are not presenting new problems, but have been given added significance by the theory of relativity.

The quantum theory is a second factor in determining this problem, and one which likewise has its source in experimental physics. This theory raises the question of the continuity of time as a basis for the physical manifold. It also leads to various conjectures concerning the meaning of change, and this in turn must affect our concept of time.

To what extent the quantum theory really necessitates any modification of the idea of time is not certain, but since the possibility of such an effect is a subject of discussion, it properly is a problem for this essay. A survey of the discussions is necessary for any conclusions.

While the developments of physics constitute the main factor in determining the new problems raised in connection with time, it should be borne in mind that there are certain factors from both biology and psychology. Particularly the theory of evolution has tended to change our view of the significance of time and also to suggest certain characteristics. This is not as novel as the physical theories. In addition, there are even more recent developments in biology, in connection with the discussions of the relation between physical and biological concepts and also the meaning of the terms "organism" and "environment" and the nature of the adaptation of the one to the other, that affect the meaning of the passage of time for a developing organism. Finally, the psychological investigation of the perception of time, as well as of the nature of experience in general, must be taken into account in any complete concept.

But it is impossible to arrive at satisfactory conclusions concerning any concept on the basis merely of recent scientific developments. These new problems can be discussed best only in the light of a historical analysis of the concepts involved. Many contemporary writers seem to assume that the problems concerning time which arise as a result of experimental science (perhaps particularly experimental physics) are entirely new problems. Before reaching that conclusion, and attempting to solve the problems as if they were novel, it would be desirable to review briefly the chief problems which have formerly been raised in this connection. One of the earliest is the relation of time and motion. This was raised at least as early as Zeno, and received further consideration by Plato and Aristotle. That there is such a relation, and that it is a necessary element in forming the concept of time, never seems to be doubted. The question of whether this is a relation of identity, of cause and effect, or some other relation was discussed with considerable insight, as will be shown in the historical chapters.

Associated with this problem are those of the relation of motion and space, of space and time, of motion and rest, and of time and rest. These discussions lead quite naturally to consideration of the relation between time and eternity. During the Middle Ages this contrast took the form of a contrast between time as measurable, therefore determined by the motions of bodies in space, and time as pure experienced duration, which applies also to God. It is obvious that these ideas, which as first stated may seem rather foreign to our way of thinking, are nonetheless concerned with problems which are still of real significance. Certainly the problem of measurement which they suggest is one which is receiving much attention and a variety of solutions at present. Both in the Middle Ages and later, it is impossible to draw a sharp line of distinction between the conceptions of measurable time and pure experienced duration. How complete a distinction is possible or even desirable can be determined only at the end rather than at the beginning of this study. In this essay the word "time" will be used for both conceptions, except where it is necessary to point out a distinction and until a conclusion as to the exact nature of the proper distinction is possible.

One phase of this question (i.e., of the distinction of time and pure duration or perhaps creative advance) is the reality or the unreality of time.[1] An associated problem is that of its objectivity or subjectivity. These are two distinct phases of the problem and should not be confused, although their solutions are not entirely independent. The problem of the reality of time is expressed in the question "Is the ultimate nature of reality eternal or temporal?" This has not been considered the most important question for this essay, although one chapter is devoted to it. The reason for giving this problem a secondary place is that the problems of the philosophy of nature seem to precede those of metaphysics. But the problem remains with a changed phrasing. Is advance, duration, process, *durée réelle* (these are more or less interchangeable terms), a real and vital or only an illusory and incidental feature of nature? How far is evolution a philosophical theory as well as a scientific hypothesis? If, in an ultimate philosophy, process is an incidental feature, is it a factor which belongs to consciousness—that is, which is subjective—or is it characteristic of all nature in independence of consciousness—that is, which is objective? With this last question the two phases of the problem coalesce. But the subjectivity of time may also be maintained if one holds that it is an essential (rather than trivial or casual) feature of reality, provided it is linked with a spiritualistic or idealistic metaphysics.

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[1] I have used the terms "reality" and "unreality" throughout the historical part of the paper because they have historical significance, although they require definition in each setting to be very significant. Real, as it generally occurs, is applied to that which is an ultimate character of our experience, one which no amount of analysis has shown to be either self-contradictory or contradictory to other accepted aspects of experience.

If the conclusion has been reached that time is real, although it be real, as Aristotle said, "in an obscure way,"[2] there is still the related problem of the nature of time. This may be seen in the contrast between its continuous and its epochal character. It involves the distinction of past, present, and future, and also that of before and after. The considerations on these points may determine one, even though otherwise not so disposed, to consider time as essentially unreal. If the present or the "now" is real in any sense, what is its nature? Can its reality be determined as a factor in experience? Is any consistent definition of the "now" possible? Can the two characters of time, continuity and atomicity, be made consistent? Can one dispose of either? This is also connected with the relation of time and motion, as is witnessed in the discussion of time in Zeno's paradoxes.

If the concept of time is approached from a little different angle, the question of the measurement of time is raised. This has been made an acute problem by the development of Einstein's theory of relativity. Is there a single time series which is an invariable constituent of nature? Until recently the almost universal answer would have been "Yes." Now, on the basis of the theory of relativity, one must answer "No," although it is possible that it may be a qualified "No." Can one answer "No" and maintain a theory which admits the possibility of measuring time? Such a theory is certainly an essential for science, but it appears that there is no generally accepted theory at present. One has a right to demand of the relativist in particular a theory of measurement since that theory depends for its discovery and proof on measurement. The basis for such a theory of measurement must be determined. A survey of the earlier theories of measurement might be helpful in formulating a theory that will fit the present state of science. Is a natural unit of measurement an essential? What is the nature of congruence which, applied to either space or time, will furnish a standard for measurement but is not itself based on measurement?

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[2] *Physica* iv. 10. 217*b*.

The problem of measurement leads back to a question already mentioned. How far are contradictory views of time due to the fact that no distinction is made between two (or perhaps more) concepts, both of which are referred to by that term and play their part in earlier discussion, only one of which has been taken over by physics? This is the distinction which is maintained by Bergson in his insistence on *durée réelle* as an objective feature of reality, which we know through *intuition*, while the time which we measure is a product of the intellect and is really space. Bergson is not alone in maintaining that there are these two elements in our uncriticized concept of time. Without any of the disparagement of science and of the intellect which Bergson asserts, Professor Whitehead holds that we must distinguish between creative advance and the various time series. The former is single, and pictured under the form of expansion, rather than as an advancing line; the latter are multiple (infinite in number), are the basis for measurement, and all of them are contained in the creative advance. There would seem to be some connection between the ideas of this analysis and earlier discussion; for example, the medieval distinction between *aeorum* and *tempus*, or that between time and eternity. There was also at least a hint of this distinction as early as Aristotle.

Thus the problem of time presents itself under many aspects, no two of which are entirely independent. Their relative importance is not always clear, but perhaps it would simplify the problem if three are considered primary: first, the contrast of measurable time and the creative advance; second, the contrast of the continuous as opposed to the atomic or epochal character of time; third, the problem of measurement.

The brief survey of the problems with which the present study is concerned leads back to the scientific theories which were mentioned at the beginning of the chapter as giving new significance to these problems. While no detailed exposition will be given of these, some statement seems necessary to show the sense in which they have determined the point of view. This essay is concerned neither with the experiments nor with the method of reasoning which have resulted in the theories themselves. Only the results are involved, particularly the concepts which are to be used in explaining our relativistic world, and the relation of these concepts as developed by physics to those previously held in that science, and to those concepts which are used in biology, in psychology, and in thinking about our immediate experience. Therefore, only such statement of the resulting theory is attempted as will show the concepts involved. This will include some analysis of these concepts showing their relation to the problem of time. The historical chapters will follow.

The theory of relativity may well be considered first. This theory indicates, in the first place, that the ordinary conceptions of space and time—conceptions depending on Newton's definition of them as objective and independent absolutes—are shown to be inadequate by the precise measurements of modern science. In the first place, space and time cannot be considered as independent but are superseded by space-time, and any measurement of one aspect involves reference to the other. The physical world, then, is one involving a four-dimensional continuum. Three of these dimensions were formerly considered space, and the fourth is time. This does not involve the idea that all four dimensions have exactly the same characteristics—for example, the time dimension may be irreversible while the others are not; but time and space as manifest in actual physical objects are not independent. Second, any exact measurement depends on the motion of both the object measured and the observer. Both the direction and the rate of motion are involved. The variations in measurement which depend on the rate of motion are negligible in most of our practical measurements. Unless the rate of motion is very great, approaching the velocity of the planets, or at least the stars, we have no instruments which can determine the effect of the motion, and we may as well assume the observer to be at rest. Even in the case of great velocities the difference in measurement can be determined only by very precise instruments and methods. For this reason the older concepts of space and time and the equations of classical physics continue to be satisfactory for all our ordinary problems. But the new concepts are of great interest philosophically. It is a mistake to consider that the theory of relativity has entirely refuted earlier physical theory; it involves rather an extension of it, and indicates that the earlier equations apply within a limited part of the universe.

The theory of relativity has also unified physics by bringing within a single set of concepts the fields of gravitation and motion, and those of electricity, magnetism, and light, which had formerly appeared as independent phenomena. A certain type of simplification has therefore been brought about by it; but not the simplification which means ease of understanding. In the most recent stage of the theory, that of Einstein's unitary field theory, this unification of principle for the field of physics is completed. It is in line with the usual development of science that progress consists in increasing unification of phenomena formerly thought to be diverse, and at the same time demonstrating more completely than before the complexity of the phenomena themselves.

The problems raised for the philosopher may be analyzed under the following heads: the meaning of the ordinary as well as the scientific notions of *space*, *time*, *motion*, and *measurement*, and the relation of scientific to immediate experience. Inevitably any statement of the conclusions about these problems indicates the general philosophical position of the writer as well as the implication of the theory itself. The most important thing to note is that space and time taken by themselves are pure abstractions; actually they always imply each other. Any measurement of them also implies reference to velocity of both object and observer. One of the points on which there seems to be most room for philosophical disagreement is the implication of this reference to the observer. By many relativists, but not by all, this is taken as evidence for a subjective view of space-time. That is, then, one of the problems to be evaluated on the basis of the historical survey.

Another problem is the extent of application of the concept of relativity. Certain writers seem to indicate that nature is entirely relative, but others indicate with considerable justification that even in the most general sort of relativity theory, some sort of absolute is implied; in fact, that no sort of meaning can be given to the term "relative" except in relation to the term "absolute."

Because of the apparent opposition between measurements of time in our ordinary experience and in certain physical experiments, there is an increasing tendency to follow the "operational" view of concepts; that is, a given concept, as time, has its meaning determined for any given setting by the operations involved in measuring it. This would suggest that the conclusions drawn by many philosophers from scientific theories are not valid. The whole controversy as to the relation of physical concepts and biological ones is significant here; that is the controversy between mechanists, vitalists, and those who hold to some sort of organic theory. Again, the historical survey should be helpful in deciding our position on this point.

In turning to an even briefer consideration of the quantum theory, it should be borne in mind that its probable effects on our philosophical standpoint will be even more revolutionary, but that the full implications of this theory can hardly be determined now. Many discussions connect it with an "epochal" view of time. This is based on the fact that while the absorption of energy is continuous, the radiation of it is in discrete corpuscles or quanta—that is, it is emitted in integral multiples of a given constant. Since this is true, the energy of a given body may have any value from 0 to ∞, but it can emit only when its energy amounts to a whole multiple of $e = hv$. The occurrence of this emission is determined by a law of probability. There are two factors in this theory which are significant in connection with the problem of time. First, the ideas of the continuity of motion and of time have always been closely associated; therefore, does this introduction of the atomic idea in connection with a certain sort of change indicate a corresponding addition to the idea of time? In other words, does the quantum theory suggest an atomic idea of time? Even in advance of our historical survey it might be noted that the progress of science has seemed to be in general an advance from an idea of continuity (e.g., matter) to one of atomicity (atoms or electric charges). Second, does the indeterminacy of quantum physics alter the traditional determinism which has been extended from science to all other aspects of our lives? Both of these problems can be evaluated only at the end of the historical survey.

There is another problem which arises in connection with the quantum theory but which suggests its connection with other sciences. How should the concept of quanta affect our ideas in such fields as the problem of the relation between an organism and its environment? The organism has formerly been thought of as set off quite definitely from its environment, but there are indications that this is not an adequate conception if we are concerned with very exact studies of the adaptation of the organism to the environment; that is, no sharp line can be drawn between them, rather we have a certain type of interrelated process. This would seem to be a development of science in just the opposite direction from that already discussed. But there is this in common: in each field there is indication that the absolute contradiction between continuity and discreteness cannot be demonstrated in nature. This suggestion of continuity and atomicity is applicable to the time of the process of adaptation as well as to the spatial or material relations.

The development of psychology, with its experiments on the individual's perception of time, and particularly those involving the *development* of the awareness of time and of the associated concept, also raises problems as to the proper elements in that concept and as to the relation between the physicist's *time*, and any aspect of our experience.

Before passing to the historical survey, it might also be pointed out that the discussion of any such problems as these must always proceed on the basis of some definite metaphysics and epistemology. These assumptions will be indicated only where the omission might result in misinterpretation. The conclusions concerning these problems may conversely affect one's metaphysical position. This will be discussed in the final chapter.

CHAPTER II

THE CONCEPT OF TIME IN GREEK AND MEDIEVAL PHILOSOPHY

EARLY DEFINITIONS AND THEIR DEVELOPMENT

One sometimes finds statements that Plato and Aristotle are the earliest philosophers even to approach a modern treatment of the problems connected with time; that before Plato all had assumed time as real and discussed merely questions as to whether we live in a universe whose succession involves dissimilar or similar moments; that Plato never clearly grasped the concept of timelessness but only the related concept of temporal changelessness; and that the only way in which Aristotle approached the modern problem was in the suggestion that he plays with momentarily—because of its numbered nature time is dependent on the mind.[1] If this is taken to mean merely that there is no discussion and solution of the problem in completely modern terms, one would naturally assent; in fact, it might be pointed out that one does not look for that until some twenty-three centuries after Plato. But if it means (and this is the natural interpretation) that there was no appreciation of the problems connected with time, it is evidently false unless subjectivity is considered to be the only modern problem. Indeed, if one is interested in the history of ideas, as well as in a solution of problems, one can find before Plato a genesis of many of the ideas about time which run through the Middle Ages and influence our modern definitions. There are four such roots which contribute to these ideas. They are those suggested by Zeno the Eleatic, Democritus the Atomist, Archytas the Pythagorean, and Hippocrates the Physician.

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[1] Cf. Van Riper, *Some Views of the Time Problem*, pp. 5–6.

Our chief source of knowledge concerning Zeno is Aristotle's *Physica*, for it is through his argument concerning motion that we can judge of his idea of time. The paradoxes of Zeno, while they in no sense indicate a developed theory of time, do show some appreciation of the fundamental problems connected with it. In a very striking way his paradoxes show up the difficulties involved in a theory which states as an attribute of time merely its continuity or its infinite divisibility. That Zeno did not formulate this difficulty clearly and adequately is true, but he had hold of a persistent problem, and therefore a real problem of philosophy, one both difficult of solution and incessantly demanding solution. It is easy to interpret Zeno's statement of this problem as being merely the problem of traversing an infinite number of points and, as has been pointed out, this is a difficulty only if one conceive of space as infinitely divisible and of time as not. But there is a deeper difficulty involved. This has recently been expounded by Professor Whitehead and will be dealt with more fully in a later section. But it is worth suggesting at this point in order that one may realize the antiquity of the problem. Briefly stated, it is that if motion is possible in a continuous space and time, one must start at the infinite end of an infinite series, for in order to traverse any distance one must first traverse the half, a division which may be carried to infinity.

Another aspect of the time problem which we can see in Zeno is the question of the relation between motion and time. Zeno did not explicitly discuss the nature of time as he did that of space, but clearly associated it very closely with motion since it is from his arguments concerning motion that we deduce his insight into the problems concerning time. The exact relation between time and motion is not discussed, but it is an important relation as the impossibility of motion follows in part from the nature of time; it is also clear that he did not identify time and motion.

Finally, Zeno pointed out the problem of measurement by indicating that "the measurement of time was impossible, as any interval of time may be equal to any part of it";[2] that on a theory of the continuity of time no unit can have any real meaning. No solution, of course, is offered, but it is clear that in seeing that there is a problem concerning measurement Zeno saw another persistent problem. And he saw that it was not merely a problem concerning the measurement of time—in fact, he does not indicate that there is a special difficulty concerning time—but a problem concerning measurement itself, based on the fact that some meaning must be given to the unit, but that any meaning seems impossible, or at least is chosen arbitrarily, if we are dealing with a continuous quantity. So it might be said of Zeno that his acuity and modernity are evident in the nature of the problems which he raised rather than in the solution which he offered.

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[2] A. V. Vasiliev, *Space, Time, Motion* (1924), p. 7. Quoted by permission of Alfred A. Knopf, Inc., publishers.

In view of their definite conception of space, the Atomists might be expected to give a clearer formulation of the problem. Actually we do not know the definite views of the early Atomists except as we suppose Aristotle's references in the *Physica* iv. 10 to be to the Atomists. Here Aristotle was explaining the impossibilities involved in a purely atomic conception of time. Furthermore, Epicurus, in taking over the atomic theory of nature, very clearly stated an atomic view of time. "Dass bereits die alten Atomiken neben den körperlichen Dingen auch die Zeit aus Atomen zusammensetzten, ist nicht überliefert; unseres Wissens ist Epikur der erste, welcher ausdrücklich die Zeit atomisierte."[3] So there is evidence of the early development of the two seemingly inconsistent yet persistent views of time—that time is continuous or that time is atomic.

If one turns from the early Atomists to the later development of their theory, one finds other problems of interest. There is a statement in Lucretius which sounds surprisingly modern. It seems, further, a quite natural development from the general atomic position and for that reason deserves a place in this section, although it is, of course, quite late. "All nature as it exists by itself is founded on two things, there are bodies and there is void in which these bodies are placed, and through which they move about."[4] According to Lucretius, there is in addition no third nature.

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[3] G. Wunderle, *Die Lehre des Aristoteles von der Zeit*, pp. 3–4.

> Time also exists *not by itself*, but simply from the things which happen, the sense apprehends what has been done in time past, as well as what is present and what is to follow after. And we must admit that no one feels time by itself abstracted from the motion and calm rest of things.[5]

Thus, by considering bodies and the void to be the only reality, or rather by furnishing only two concepts of explanation, Being (bodies) and Non-being (void), the Atomists touched upon the question of the reality of time. They seem to deny it complete reality, but at the same time they hold that it is a predicate applicable to the two realities—void and bodies—and therefore having a certain real, though derivative, character.

This line of thought, in its general atomistic development, has its culmination in Gassendi. According to Gassendi, there are three realities (two of which are the same realities as those posited by Lucretius): void, bodies, and the universe. The last is the organic total of the other two. Time was not introduced by Gassendi (as it was by Aristotle) as dependent on motion, but as that which is prior to motion. It is like substance in that it is not dependent on its content or on anything for its being. It is incorporeal. It is the "duration of all durations,"[6] or perhaps the sum of all times. In opposition to the general Epicurean view and in accordance with the realistic view, Gassendi did not make time dependent on minds; it is that from which events derive their order. Gassendi was led to one inconsistency with regard to time which should be noted in particular. He repudiated any distinction between real or experienced time and imaginary or conceptual time. This involves, finally, the statement, seemingly quite at variance with our usual experience (at least at variance with the general or common-sense views of it), that time is either experienced as a whole or not experienced at all.[7] Again there is the problem which Zeno attempted to phrase—a problem seemingly insuperable—that concerning the infinite divisibility of time. One further remark is made about Gassendi by Brett, and one which might indicate a much deeper grasp of the general problem of time than has generally been accorded him.

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[4] *De rerum natura*, trans. Munro, i. 419–21.

[5] *Ibid.*, 459.

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[6] G. S. Brett, *The Philosophy of Gassendi* (1908), p. 41. By permission of the Macmillan Co., publishers.

> The most noticeable feature is his omission of any distinction of the psychological aspect, an omission which compels us to take his "moment of time" as an absolute quantity. While he is clear about the artificial measurements of time, he does not oppose them to the subjective measurement of time, as modern psychology does, but to real parts; a proceeding which is certainly consistent with his view of time as a whole in some sense substantive.[8]

Further it should be noted that this is a proceeding which would seem to indicate a promising line of attack. The tradition started by the Atomists is of importance in determining the concept of time as well as the general analytical position of the natural sciences at the beginning of the modern period of thought.

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[7] *Ibid.*, p. 44. Gassendi never actually made this statement, but it is implied.

[8] *Ibid.*, p. 45.

This is evident in the discussion of time by Descartes and that by Newton.

In considering the Pythagoreans, one is hindered by an uncertainty of sources. There seems to be no definition of time which dates before Archytas, so this part of the discussion has to do with a definition contemporary with Plato and the later developments of this definition rather than with one preceding Plato. It is included in this chapter because it clearly had early sources. In his discussion of the infinite[9] and of the void,[10] Aristotle furnished us with a reference to the Pythagoreans which at least apparently is to Archytas, and involves his definition of time. Following Simplicius,[11] Zeller attributed a vague statement concerning time to Archytas,

> Beyond the circle of fire lay the Unlimited, or the unlimited air [πνεῦμα] from which the universe draws its breath. That there must be an Infinite of this kind outside the world Archytas had proved. From it time as well as the void had entered the world.[12]

In another place Aristotle said that the Pythagoreans identified time with the celestial sphere. "The former doctrine involves the concept of time as without limit, the latter asserts that the sky by its motion is the measure of time."[13] This would involve the notion of a limited time. Zeller[14] maintained, and there is a good deal of evidence, that these two doctrines existed as Pythagorean but probably with no attempt at reconciliation.

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[9] Aristotle *Physica* iii. 4. [10] *Ibid.* iv. 6.

[11] Cf. *In Aristotelis Physicorum libros commentaria*, ed. Diels, p. 786.

[12] *History of Greek Philosophy*, I, 467. Reprinted by permission of Longmans, Green & Co.

There is another reference in Simplicius to the view of time taken by Archytas. In his commentary on the *Physica*, he attributed to Archytas on the authority of Iamblichus a definition of time as "a certain number of motion or the universal extension of the nature of the universe."[15] It should also be noted that Zeller did not consider that this definition dates from Archytas. But whoever originated this definition, it must be considered as of early date and as having an important later development.

In this definition there are two elements which were taken up by different men and became embodied in two different traditions concerning the nature of time. That time is a "certain number of motion" is an idea adopted by Aristotle and one which will be discussed later in this essay. It is the second part of the definition which is of interest here. From the *Fragments of Zeno and Cleanthes*, by A. G. Pearson, we can see that this definition was taken up by Zeno (the Stoic): "Zeno showed time to be the interval [διάστημα] of motion, or the measure or standard of it and the manner of speed and of slowness. But in Zeno time is merely the interval of all motions."[16] His successor, Chrysippus, limited this definition by adding the words "of the world." "Zeno held as against Chrysippus that time existed from eternity, and that it is not merely coeval with the phenomenal world."[17] Chrysippus' limitation of the definition of time brings to light one of the real problems connected with time.[18] He distinguished between determined or measurable time as related to real being (ὄντι) and the indefinite time which Zeno meant. This distinction accounts also for Chrysippus' denial that time could have existed from eternity; for time as measurable is dependent on the phenomenal world. In the Stoic school itself there was much controversy on the question of the extent of time, whether it is infinite or coeval with the existence of the world. The particular points of interest here are the recognition (although vague) of the dual character of the concept of time, as indefinite duration versus measurable or definite duration. Closely connected with this is the recognition of the need of a theory of measurement and that any such theory must depend on structure. This structure is supplied in Stoic philosophy by the moving bodies in space rather than by any character of time or duration itself. It should be further pointed out that pure duration is in this view divorced from motion.

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[13] *Ibid.*, p. 469.

[14] *Ibid.*, p. 470.

[15] *Op. cit.*, p. 786.

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[16] P. 130.

[17] Stein, *Erkenntnistheorie der Stoa*, pp. 223–25; quoted from Pearson, *ibid.*, p. 130.

[18] Cf. Brehier, *La Théorie des incorporels dans l'ancien stoicism.*

Another characteristic development of this definition is the unreal character it attributes to time. This seems due to two factors. The first is the fact that time does not effect the succession of events at all. The Stoics tried to reconcile the existence in time of all beings and of God, with necessity and perfection, and therefore they deprived time of all real existence and all action on beings.

Neither of these seems to be an inevitable result of the original definition, but one finds that the same tendency to make time unreal always accompanies this definition.[19] This is made clear in his *Note on Crescas' Definition of Time* and *Crescas' Critique of Aristotle*, by Professor H. A. Wolfson. He shows first the prevalence of this definition among the Arabic and Hebrew authors. But before going into this development let us see what use Plotinus made of this definition. In the *Enneads* iii. 7. 6, Plotinus gave a review of all previous definitions, and among others the one which defines time as the interval or extension of motion, that is, διάστημα.[20] In chapter 7 Plotinus showed its relation to quantity and to space and hence to duration. Although this is not the definition of time actually adopted by Plotinus, we shall see in a later section that it may have had some influence on him, or at least that certain developments in his philosophy are comparable to those generally accompanying this definition.

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[19] It is quite possibly really dependent on the general metaphysical position of the Stoics rather than on their definition of time. Cf. below, the discussion of McTaggart and the other Absolutists. I am not certain whether this is due to their monistic metaphysics or to what Professor Northrup calls "the mathematical theory of nature" (*Science and First Principles*, pp. 11 ff.). This asserts that because of the increased understanding dependent on a mathematical approach to nature, the real is rational. Certainly those who adopted this definition of time also asserted the rationality of nature. This metaphysical bias would account in part for the fact that their definition became associated with the Platonic definition.

[20] H. Wolfson, *Crescas' Critique of Aristotle* (1929), p. 654: "In Plotinus we have the clearest and probably also the first statements on the identification of time with duration." Reprinted by permission of Harvard University Press.

This definition, always using some word for duration, is found very frequently throughout the Arabic and Jewish philosophers, very often with the Aristotelian definition next it and not always clearly distinguished from it, although they were originally different. Explicit reference is here made to only one of these writers, and for him the authority is Wolfson's discussion in *Crescas' Critique of Aristotle* and his *Note on Crescas' Definition of Time.*

In Crescas the implication of this definition is stated clearly, for following the definition he said: "Consequently it may be inferred that the existence of time is only in the soul."[21] Quoting further from Wolfson:

> According to this view time is absolutely independent of motion, magnitude and space. It could have been conceived by mind even had there been no external world in existence. We thus again find Crescas contending, as a consequence of his definition of time, that the statement of R. Judah bar R. Simon that the order of time had existed previous to creation (Bereshit Rabba, ch. III) should be taken in its literal sense.[22]

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[21] *Note on Crescas' Definition of Time*, p. 5.

[22] *Ibid.*, p. 10.

In this line of thought we see the beginnings of the distinction between time as ideal, and therefore indefinite and immeasurable, and time as measured, which involves a connection with motion or space or both. This will be further discussed in the section on the Aristotelian definition and its developments. It will also reappear in the discussions of Descartes—of Spinoza's distinction of time and duration—and of Bergson's *durée réelle* as opposed to spatialized time.

Although Augustine's general discussion of the problem of time falls rather in the Platonic development, some points can well be mentioned here. Time is coexistent with motion, but he used the term *distentia*. After a long discussion of various definitions, he concluded, "I perceive time then to be *a certain extension.*" Thus bringing him in line with the development just discussed. There are also important subjective elements in his discussion, for in this very place he continued, "But do I perceive it, or seem to perceive it? Thou, Light and Truth, wilt show me." Eternity also, which may be in some aspects compared to the duration of the non-Aristotelian definition, is a subjective aspect of God's life. The subjective element in

Augustine's theory goes even further since measured time, although objective in the sense of dependent on motion, is subjective in so far as it is measurable. This seems to be more in line with the Aristotelian development than any other.

It is also clear from these discussions that there are two quite distinct problems, one of which may be termed the *reality* versus the *unreality* of time; the other the *reality* versus the *ideality* of time or the *objectivity* versus the *subjectivity*.

It is evident that many of the definitions which use the term "extension" as the key imply the idea that time is real, in the sense that it is not derivative from some more primary character of experience. Nevertheless, this is combined with the view that time is subjective or idealistic. At least as far as the Arabic and Jewish writers are concerned, this subjective factor may be derived from the Plotinian definition.[23]

This definition is in complete contrast with the Epicurean view, which made time objective enough, but unreal in the sense that it makes no difference to bodies and in the fact that "time also exists not by itself, but simply from the *things which happen the sense* apprehends what has been done,"[24] that is, time was not thought of as a primary concept but as the product of relations among things. The Stoic view, on the other hand, although it was similar in many respects to the subjective definition, implied that time is unreal in the sense of making no difference, while the Aristotelian definition made time out to be objective enough but dependent on motion and to that extent lacking complete reality.

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[23] The influence of Aristotle and Plotinus on these writers is summarized by Wolfson in *The Philosophy of Spinoza* (1934), I, 332–41.

The definitions so far considered, then, allow scant reality to time—it is either completely unreal as contradictory or it is insignificant, or at least it is subjective as dependent on mind.

This chapter includes a brief reference to Hippocrates, not because of any specific definition of time, for I could find none in his works, but because of certain assumptions of his which indicate a different attitude from any of those already discussed. It is a point of view which reappeared in Aristotle's biological treatises, although it does not influence his definition of time as far as I can see. This point of view seems quite in line with the view that time is a real character of the organism, a view which will be discussed in connection with the development of the biological theory of evolution, and also the general organic view of the twentieth century. (This is the view which Professor Northrup calls "functional" as distinguished from the "mechanistic" and from the "mathematical" views.) Hippocrates indicated a general opposition to the use of hypotheses in medical practice—by which he intended to lay down a basis of empiricism based on direct observation. His observations are colored by certain assumptions; for example, his whole discussion of disease indicates that the effect of the passage of time upon the organism is of real significance. Thus it appears that recovery from disease or injury is an active process, independent both of volition and of artificial aid.[25] There is a positive tendency of the organism to recover, provided the conditions of the environment are made favorable, or even without this. The insistence on this tendency would seem to rest on the assumption of the reality of the time process.

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[24] Lucretius *op. cit.* 159. (Italics mine.)

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[25] Cf. J. S. Haldane, *Philosophy and the Sciences*, p. 58.

Also it is clear that Hippocrates was influenced by Heraclitus. In his treatise on diet he spoke of a steady and ceaseless transformation of matter.[26] This suggests both a view that time is real, in the sense of affecting immediately perceived reality, and a view that it is continuous and regular. The same tendency to take the view that time is continuous is indicated in his opposition to the current medical practice, which considered that certain days are arbitrarily significant in certain diseases.

This connection of time with life-processes seems to have been of little significance philosophically until much later, perhaps until the nineteenth century, but I cite it here as indicating one root of the view of time which is connected with the biological view. It might be a fruitful study to trace this view in the development of medicine and of biology but it is not attempted in the present essay.

THE PLATONIC TRADITION

It has already been pointed out that it is impossible to separate completely the philosophical from the scientific conception of time, but if science is limited to natural science and if pure mathematics is considered as part of philosophy, there is, during at least the ancient and medieval period, a line of development of the concept of time which is chiefly philosophical. This line was started by Plato. While there are several passages in which he dealt in an incidental fashion with problems connected with time (*Laws* 676; *Republic* x. 608; *Parmenides* 141, 152–57; *Phaedo* 107), the only passage in which he explicitly discussed it is in the *Timaeus* 37*c*–38*d*. Here is the source of one of the characteristic ways of describing time by contrasting it with eternity. In endeavoring to make the universe as similar as possible to the eternal pattern, since the universe could not be eternal, the demiurge

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[26] Moon, *Hippocrates and His Successors*, p. 53.

> resolved to make a moving image of eternity, and as he set in order the heaven he made this eternal image having motion according to number, while eternity rested in unity; and this is what we call time. For there were no days and nights and months and years before the heaven was created. . . . . All these are the parts of time, and the past and future are created species of time. . . . . These are the forms of time when imitating eternity and moving in a circle measured by number.[27]

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[27] Plato *Timaeus* 37. All quotations from Plato are from the Jowett translation, reprinted by permission of Oxford University Press.

If this picture of the coming into being of time is considered, bearing in mind that it is but a picture, it reveals three of the significant aspects of time. First, it is "a moving image," and thus is in intimate connection (though not identical) with change. This brings it in line with the view that time is continuous. Second, it is "an image of eternity," and thus possesses a certain completeness—is, in fact, a whole for itself possessing those characteristics which suggest an epochal theory of time. Third, days, months, years, the past and future are "forms of time, when . . . . moving in a circle measured by number," and thus time is such that it is embodied in concrete events and attains a measurable aspect. There is reference to the measurable character again in the *Timaeus* 38: "He made the sun and moon and five other stars, which are called the planets, in order to distinguish and preserve the numbers of time." It is to be noted that the numerable or measurable aspect of time is not achieved in its embodiment in events but may be distinguished through that embodiment. This is, of course, in accord with Plato's realistic position and with his adherence to the mathematical view of nature.

The discussion of time is very far from being a central part of Plato's philosophy, and it is, therefore, merely pointed out that these aspects of time may be seen in his figure. The figure itself is particularly important from a historical point of view, for it was taken up and made the starting-point for other discussions of the nature of time.

In a book entitled *Die Begriffe der Zeit und Ewigkeit in späteren Platonismus*, Dr. Hans Leisegang traced the development of this idea of the relation of time and eternity through the writings of Plutarch, Philo, Plotinus, Iamblichus, Proclus, and Damascius. These all show the influence of the Platonic discussion although their definitions may not be actually Platonic. For example, Plutarch employed both the Aristotelian and the Stoic definitions of time as exhibiting certain qualities of time but as failing to emphasize its essential nature, which is to mirror, through that which moves, the eternity of the Deity. Philo employed the Stoic definition of time as the extension or interval of the movement of the universe, but modified this by the Platonic contrast with eternity.

Passing briefly over these two writers, the next is Plotinus. He gave a very full and significant discussion of time in the *Enneads* iii. 7. He began by pointing out that while we usually consider time and eternity as quite distinct, we do not really know what they are. An inquiry as to their nature is therefore in order. He first discussed eternity. We find that its characteristic is unity in variety. "We know it as a Life changelessly motionless and everholding the universal content (time, space, phenomena) in actual presence." Its definition may be thus stated: "The Life—instantly entire, complete, at no point broken into period or part, which belongs to the authentic Existent by its very existence, this is the thing we were probing for—this is Eternity."[28]

Coming next to the question of time, he reviewed briefly all former definitions on the assumption that somewhere among the ancients we may find an adequate statement. Of these he pointed out three classes of definitions—time is either (1) movement, (2) the object moved, or (3) an accident or attribute of movement. These were all found to be unsatisfactory. The nature of time can be seen best by inquiring as to its emergence from eternity; thus the Platonic figure became his clue.

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[28] iii. 7*B*; trans. Mackenna, II, 99–100. Reprinted by permission of Hale, Cushman & Flint, Inc.

Time lay self-concentrated, at rest within the Authentic Existent: it was not yet Time; it was merged in the Authentic and motionless with it but there was an active principle there . . . . and it chose to aim at something more than its present; it stirred from its rest and Time stirred with it. And we [i.e., human souls as summed up in the principle of developing Life, the All-Soul], stirring to a ceaseless succession, to a next, to the discrimination of identity and the establishment of ever new difference, traversed a portion of the outgoing path and produced an image of Eternity, produced Time. . . . . To bring this Kosmos into being the Soul first laid aside its eternity and clothed itself with Time . . . . making it [i.e., this world] at every point a thing of Time. For the Kosmos moves only in Soul—the only Space within the range of the All open to it to move in—and therefore its Movement has always been in the Time which inheres in Soul. . . . . The Soul produced *succession* as well as *act*. . . . . Time, then, is contained in differentiation of Life; the ceaseless forward movement of Life brings with it unending Time; and Life *as it achieves* its stages constitutes past Time. Would it, then, be sound to define Time as the Life of the Soul in movement as it passes from one stage of act or experience to another? Yes. . . . . We are brought thus to the conception of a Natural Principle—Time—a certain expanse [a quantitative phase] of the Life of the Soul . . . . a Principle, then, whose Act is [not one like that of the Supreme but] sequent. . . . . It is that in which all the rest happens, in

> which all movement and rest exist smoothly and under order; something following a definite order necessary to exhibit it and to make it a subject of knowledge—though not to produce it—it is known by order whether in rest or in motion. . . . . Plato does not make the essence of Time consist in its being either a measure or a thing measured by something else. . . . .

Time should not be associated merely with movement of material bodies—it is a product rather of the movement of the Soul.

> . . . . Time is in every Soul of the order of the All-Soul, present in like form in all; for all the Souls are the one Soul. And this is why Time can never be broken apart, any more than Eternity which, similarly, under divine manifestations, has its Being as an integral constituent of all the eternal Existences.[29]

This rather extended series of quotations from Plotinus has been given because they illustrate the way in which he developed the various aspects of the nature of time which were noted in Plato's treatment. If time is to be described as accurately as is possible, it should be done not in the abstract terms of measurement but in terms of a life which is achieving definite stages. This achievement of a stage within the process is a mirroring of the unitary character of the life of the soul. Each stage is in itself a whole, but, unlike the Whole which is eternal, they are temporal and as such are successive wholes or successive acts. Thus, there is clearly implied a recognition of both the epochal and the continuous character of time. This dual character of time is not only exemplified in the life of the world-soul, but also in the life of every individual soul. This should be kept in mind in connection with the later psychological discussion of time.

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[29] The quotations are from *ibid.* 7, 11; trans. Mackenna, II, 113–19.

But while it is in terms of life that the nature of time is portrayed best, time is also known to us as measurable. It is through time that magnitudes of movements are observed, and through the repeated observation of movement that the idea of a definite quantity of time is reached. This comes about by observing the temporal process as expressed in concrete events, in sensible objects rather than as expressed in the acts of the soul itself. Again this discussion of the measurable aspect of time as distinct from, but dependent on, its relation to life is not unlike many modern discussions.

The treatment outlined in Plotinus is continued with some variations in many other writers.[30] Iamblichus, for example, defined time as the essential movement of the soul. Proclus departed from the tradition in a more marked way, for he did not accept the dependence of time for its existence on the nature of the world-soul. Time is completely independent of the soul for its being—on the contrary, the soul must take time as a standard in ordering things. Damascius, likewise, did not bring time into direct dependence on the soul but found a corresponding principle in the movement of things and of the soul. Thus, in the development of Neoplatonic thought there was a tendency to emphasize the objective character of time. This tendency was quite in agreement with the Aristotelian source of their thought.

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[30] Leisegang, *Die Begriffe der Zeit und Ewigkeit in späteren Platonismus*, pp. 29 ff., 42 ff., and 48 ff.

The next treatment to be considered is that of Augustine. This was in very close accord with that of Plotinus, but it added new elements to the concept and developed those already there. It was in line with two factors in his philosophy—Neoplatonism and Christianity. In *The Confessions* (Book xxi), and in *The City of God* (Book xi), Augustine dealt with the problem of the creation of the world as set forth in Genesis. His discussion of time arose in an attempt to answer the question, "What did God *before* he created the world?" In *The Confessions*

xii. 10–61 he discussed certain false views as the age and duration of the world and other problems connected with the beginning of time. There were at least two important phases in his treatment of time—the cosmological and the psychological. They were not independent but very clearly related; the second grew quite naturally out of the first. Although his discussion started with the interpretation of Genesis, as far as the question of time is concerned it is more definitely related to Aristotle and to Plotinus.

Almost at the start of his discussion is the following statement, which voices very eloquently the difficulties involved in any discussion of time:

> But what in speaking do we refer to more familiarly and knowingly than time? And certainly we understand when we speak of it; we understand also when we hear it spoken of by another. What, then, is time? If no one ask me, I know; if I wish to explain to him who asks, I know *not*.[31]

He continued with an analysis which assumed two facts, the eternal and therefore changeless nature of God, and his creation of the world

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[31] *Confessions* xi. 14.

"in the beginning." The distinction between time and eternity was immediately made:

> For if eternity and time are rightly distinguished by this, that time does not exist without some movement and transition, while in eternity there is no change, who does not see that there could have been no time had not some creature been made, which by some motion could give birth to change, the various parts of which motion and change, as they cannot be simultaneous, succeed one another,—and thus, in these shorter or longer intervals of duration, time would begin.[32] . . . . But time passing away by its changefulness cannot be coeternal with the changeless eternity.[33]

That he thought eternity was really superior to time is brought out in his emphasis on the eternal nature of God:

> Nor dost thou by time precede time; else wouldst not Thou precede all times, but in the excellency of an ever-present eternity, Thou precedest all times past, and survivest all future times, because they are future, and when they have come they will be past; but Thou art the same. Thy years shall have no end.[34]

This clearly involves the assertion of the fundamental distinction between eternity as changeless and time as dependent on motion or change. Besides this, there is the statement that because

[32] *City of God* xi. 6.

[33] *Ibid.* xii. 16.

[34] *Confessions* xi. 13.

of the eternal nature of God it is necessary that some creature exist and change if time is to exist, since time is not a part of God's nature. That this creature is the world is evident from the statement in Genesis that "in the beginning God created the world." Therefore the world and time came into being simultaneously. In this opinion Augustine was like Plato. "But simultaneously with time the world was made, if in the world's creation change and motion were created, as seems evident from the order of the first six or seven days."[35] This is also brought out in his discussion of the changeable earth as he observed that its "very changeableness appears in this, that times can be observed and numbered in it."[36] This dependence of time on some creature capable of change is referred to later.

> Without the change and number of motions times are not, and there is no change where there is no figure. . . . . If nothing were passing away, there would be no past time; and if nothing were coming there would be no time to come; and if nothing were, there should now be no present time.[37]

Present time, as present, is dependent only on the existence of something, but if this existence were changeless, then the present would be indistinguishable from eternity. This is suggested: "As for the present should it always be present and never pass into times past, verily it should not be time but eternity."[38] Time is dependent, then, on the existence and changeable character of some creature, actually of the world. However, Augustine distinctly denied that time is the motion of anything, as of the sun, moon, or stars. He suggested that a day of twenty-four hours is the time in which the sun moves around the earth, and asked whether if the sun moved around the earth in an hour, would that be a day, or must the sun move around twenty-four times at that rate to make a day. At this point he included a definition which seems Aristotelian: that time is that by which we measure the motion of a body. "Since then the motion of a body is one thing, that by which we measure how long it is another, who cannot see which of these is rather to be called time."[39] He further suggested that had there been a creature before the world, there might then have been time. He actually mentioned two creatures as before the world, i.e., the Void and the Heaven of Heavens. The former was formless and could not change and therefore did not involve time. No explanation is given as to why the latter did not involve time. These two creatures are outside of time but not coeternal with God. That there should be a creature involving time prior to the creation of the world he considered contrary not to reason but to the Scriptures. The question might be raised here as to how far Augustine's theory is compatible with the modern theory of relativity, provided his view could be freed from its dependence on the Scriptures and on the astronomical view of his period. If time were dependent on the motion and change of this world and the world were considered the center of the universe, it would be inevitable that one should think of time as pervading the universe. But if another creature might involve a different time, as is certainly suggested, then it is quite possible that if he had held to a modern theory of astronomy Augustine would have conceived of different time systems for different states of motion. This, of course, connects with the problem of measurement; but even before that is discussed, these points should be noted as indicating the modern character of his treatment.

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[35] *City of God* xii. 16. [36] *Confessions* xii. 8. [37] *Ibid.* xi. 11 and 14.

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[38] *Ibid.* 14.

[39] *Ibid.* 24.

There is another problem as to the nature of time which must be discussed before that of measurement. Augustine approached it when he pointed out that we speak of three times (past, present, and future) rather than of one. In this problem comes the transition from the cosmological to the psychological treatment of time. Augustine pointed out that in this threefold time we see its ideal or derivative nature. All three—past, present, and future—depend on the existence of something else.

> If nothing were passing away there would be no past time, etc.[40] . . . . . Furthermore, those two times, therefore, past and to come, in what sort are they, seeing that the past is now no longer and that to come is not yet?[41]

But even this does not reveal the full paradox.

> As for the present should it always be present and never pass into times past, verily it would not be time but eternity. If then time present, to be time, only comes into existence because it passes into the past; how can we say that also to be, whose cause of being is, that it should not be?[42]

But still time past and time future have some being, as is witnessed by the facts of memory and expectation. "Wheresoever, therefore, and whatsoever they be, they are not but as present."[43] They are all present as in the mind and should be called "a present time of past things" and "a present time of things to come." The conclusion here would seem to be in favor of a subjective theory of time. The apparent inconsistency of this may be due partly to failure to see this in its context and partly to the same difficulty that many find in following the arguments of those modern physicists who, making the perception of time dependent on the rate of motion, also hold that this is evidence for a subjective interpretation of time.

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[40] See above, p. 48, and *Confessions* xi. 14.

[41] *Ibid.*

[42] *Ibid.*

Closely related to this problem of past, present, and future is that of the measurement of time. How can past time, which is no longer, or future time, which is not yet, be measured "unless perchance some one man be so bold as to affirm that that may be measured which is not"?[44] "How, furthermore, can we measure present time, since it can take up no space?"[45] Yet in spite of these statements Augustine was confident that we do actually measure time. As nothing can be found in the cosmological explanation of time (i.e., in its nature in itself) to explain how this occurs, he fell back on a psychological explanation: "In thee, O my mind, I measure times."[46] The mind is able to compare intervals as they are passing. Times past or future can be said to be long or short only as their memory or expectation is long or short. Yet a subjective basis for measurement can never be convincing and Augustine's certainly is not.

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[43] *Ibid.* 18. [44] *Ibid.* 16. [45] *Ibid.* 21.

There is only one suggestion which he makes as to a basis in the world for these measures. "A long time cannot be made long but out of many motions still passing onwards, which cannot at the same instant be drawn together."[47] While this connects the measurement of time with actual motion and with rate of motion, it is in no way comparable to the theory of relativity, which holds that time is slowed up by great velocities. Nor is it in accord with the findings of psychology on the perception of present time, i.e., psychologists have found that time in which many changes occur is perceived as short, although it is remembered as long. The facts of memory, however, are in agreement with Augustine, that an interval during which there was much going on is remembered as long.

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[46] *Ibid.* 27.

[47] *Ibid.*

In conclusion, the comprehensive character of Augustine's treatment should be emphasized; he dealt with the real (ultimate) as opposed to the ideal (derivative) character of time, with its nature as continuous, and as atomic, with the question of its beginning and in connection with this at least hinted at the possibility of there being several times (i.e., if there had been another creature before the world). In that, and in the emphasis on its relation to mind, he most nearly approached the problems raised today in connection with time. In this connection it should be noted that in his discussion of measurement he emphasized one point which all should bear in mind. While measurement of time undoubtedly takes place in the mind and is dependent to some extent on the observer, still we must find the justification for this measurement in some structure of external reality.

This discussion has been treated at such length because Augustine furnished a valuable summary of the general tendency of the Platonic (philosophical) treatment of time. While, as has been pointed out, it bears certain analogies to the Aristotelian treatment, still in general it is an example of an idea of time arrived at through the contemplation of the nature of the eternal and of the mind. In rather marked contrast to this is the Aristotelian point of view with its scientific method of approach. Whether the results furnish the same contrast which the method does is a problem that can be discussed only after a more complete description of the Aristotelian conclusions.

THE ARISTOTELIAN TRADITION

Turning from the philosophical treatment, the method of definition and description which are to be discussed now might be termed the scientific definition of time; at least it is more akin to our general notions of science since it is concerned with time only as a phenomenon of this world and does not depend for its description on a contrast with eternity. However little contrast there may be in these conclusions from the conclusions just discussed, certainly the method is different from that of the philosophical tradition. It might also be pointed out that the works of Aristotle contain the earliest discussion of time which definitely brought up the various problems and attempted to offer a systematic solution of them.

The discussion of the nature of time is given most completely in the *Physica*, and, as one would expect, follows after that of space, but is much less naïve. Aristotle pointed out that there are two main questions: as to the being and as to the nature of time.

> To start, then: the following considerations would make one suspect that it either does not exist at all or barely, and in an obscure way. One part of it has been and is not, while the other is going to be, and is not yet.[48] . . . . For what is "now" is not a part: a part is the measure of the whole, which must be made up of parts. Time, on the other hand, is not held to be made up of "nows."
>
> Again, the "now" which seems to bound the past and the future—does it always remain one and the same or is it always other and other? It is hard to say.[49]

If it is changing there must be some underlying ground of the change (cf. his argument concerning matter); nor is it possible that the present continue as itself, for in that case those things which are earlier and later for a particular present would be so a thousand years hence. The only conclusion is that time exists in an obscure way. Aristotle thus avoided making

[48] iv. 10. 217*b*. All quotations from Aristotle are from the Oxford translation edited by Ross. Reprinted by permission of the Clarendon Press, publishers.

[49] *Ibid.* 218*a*.

time real (actual); on the other hand, since he found that it has a certain reality, he proceeded to the discussion of its nature.

Before passing to his actual definition and discussion of time, it might be well to note that Aristotle's biological discussion should have led to a more unequivocal assertion of the reality of time. That is, time is real in the sense that it makes a difference to the developing organism and indeed is a factor necessary to this conception. This view affected his general metaphysical position, but Aristotle was never quite ready to attribute full reality to time. That full reality is implied in the idea of a developing organism had already appeared in Hippocrates' work, and it was to appear again in the nineteenth century in connection with the biological theory of evolution.

He mentioned, but did not think it worth actual consideration, the notion that time may be the sphere of the universe. He also discarded the idea that it is the movement of this sphere, because in that case, if there were more than one universe, there would be more than one time. The next suggestion was that it is movement, and this again is refuted by the necessary unity of time, for while some movements are fast and others slow, there is only one time. Instead of time sometimes being fast and sometimes slow, as would follow if time were motion, it is time which determines whether movements are fast or slow. Also, movement is either in the thing changed or where the thing is, while time is everywhere.

Nevertheless, Aristotle concluded that time implies change. If there is no change in our consciousness, it appears to us that no time has passed. Therefore, although time cannot be movement, it must be related to movement or an attribute of movement. Movement involves space and also takes place in time. Aristotle had already found that spatial magnitude is continuous. Movement also is continuous, because it is movement through a continuous space; and time, then, is continuous because occupied by continuous movement. On the other hand, because of this same relation between time, movement, and space, it comes about that time is characterized by "earlier and later." From this followed his definition, "Time is number of movement in respect to the before and after."[50] We know more and less through number but more and less change through time. Number is used not to mean the means of counting but that which is counted.

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[50] *Ibid.* 11. 220*a*.

Aristotle's representation of time as a line, which occurs at this point, is significant. Time may be represented as a single moving body observed at different stages. The thing which moves is the "now"; through this now, time gets both its continuous character, since now is always one and the same, and its differentiation into parts, since now is always changing. But the nows are not parts of time any more than points are parts of a line. Time is a quantity, continuous and divisible.[51]

Turning from the *Physica*, there are similar passages to be found in both the *De generatione et corruptione* and the *Metaphysica*.

> Since time is continuous, movement must be continuous, inasmuch as there can be no time without movement. Time, therefore, is a "number" of some continuous movement—a "number," therefore, of the circular movement as was established in the discussions in the beginning.[52] . . . . Of things that are quantities incidentally some are . . . . , and some are quantities in the way that movement and time are so; for these are called quantities and continuous because the things of which they are attributes are divisible. I mean not that which

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[51] Cf. W. D. Ross, *Aristotle*, p. 89.

[52] *De generatione et corruptione* 337*a*. 22–33.

> is moved but the space through which it is moved; for because that is a quantity movement also is a quantity and because this is a quantity time is so.[53] . . . . Nor can time come into being nor cease to be; for there could not be a before and after if time did not exist. Movement also is continuous, then, in the sense in which time is; for time either is the same thing as movement or an attribute of movement. And there is no continuous movement except movement in place, of this only that which is circular and continuous.[54]

In both the *Physica* and the *De caelo* the statement is made that there is no minimum of time.[55] This is evidence for the fact that Aristotle was concerned chiefly with the continuity of time rather than with the atomic conception. This should be borne in mind throughout the later discussion.

The *Physica* also contains passages referring to rest. Things are always changing through time so that which is always (eternal) is not in time. As time is the measure of movement, it is also the measure of rest. There can be things at rest only in respect to something which changes. The present is the source of the continuity of time, for it joins all parts together; it is also the limit, for it is the end of one and the beginning of another.

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[53] *Metaphysica* v. 1020*a*.

[54] *Ibid.* 1071*b*.

[55] Cf. *Physica* 220*a*. 27–32.

Then Aristotle raised the question whether, since time is number, it can exist apart from the soul. This is not fully answered. If there is no soul, there is no counter, and therefore nothing counted, or no number, which is to say no time. But there would still be movement, and thus, in a sense, time could exist without the soul.

Before attempting any estimation of this idea of time, it would be well to deal briefly with the idea of motion, since the two are so closely connected by Aristotle. Movement in its widest sense equals change (μεταβολή). This is the substrate of time. Aristotle also used the word κίνησις in practically the same sense. There are four kinds of change: substantial change, qualitative change, quantitative change, and locomotion. The second and third can be reduced to the last, and are the basis of time. Substantial change, on the other hand, is timeless. Aristotle's statement then amounts to saying that time is the number of locomotion. As has been noted before, time is continuous, and this could be true only of the number of the most perfect motion—that is, of circular motion.

In the analysis given in the *Physica* it appears that there are at least two essential ideas involved in the concept of time. The first, movement, has been discussed. The other is the "now." This now has a dual character. It is the end of the past and the beginning of the future. As such it has no actual existence, merely potentiality. Looked at in this way, the now is ever changing as the past encroaches upon the future. From this character of the now, time gets its quality of succession, or number. But the now is not only changing; in another sense it is always the same. It is due to this quality that time is also continuous, or is a measure. This is summarized by Wunderle: "Time is the number and measure of movement according to before and after, i.e., it is the numbered succession and measured continuity of movement."[56]

In dealing with time in so far as it is determined by movement, the objectivity of time is naturally emphasized. This is the characteristic Aristotelian emphasis. But in view of the development of the Kantian conception of time

[56] *Op. cit.*, p. 40. (My translation.)

as a form of perception, it should be noted that Aristotle raised the question of the relation of time to consciousness. While he suggested that time is dependent on the function of the soul in numbering, still time as derived from movement is in that sense independent of the soul. It is wrong, therefore, to read into Aristotle a complete Kantian transcendentalism. The objective concept is decidedly the predominant one. The most that can be said is that he considered the opposing view.

As has already been indicated, Aristotle emphasized the conception of time as continuous. This character is due to its relation to movement and space. But this is not the only aspect of his treatment. Two things show that he recognized, at least dimly, its epochal character. In considering what is meant by calling time a continuous quantity, the definition must be examined in both parts, both as to what is meant by continuous and as to what is meant by quantity. In the *Metaphysica* quantity is defined as "that which is divisible into two or more constituent parts of which each is by nature a 'one' and a 'this.'"[57] Quantity is either (*a*) plurality, which is equal to a

[57] *Metaphysica* 1020*a*.

numerable quantity or divisible potentially into non-continuous parts, or (*b*) magnitude, which is equal to measurable quantity or divisible into continuous parts. Time is a magnitude or divisible into continuous parts.

The definition of continuous should be considered first. This occurs in essentially the same form in three places: *Metaphysica* xi. 1068*a; Physica* vi. 226*b*–227*b;* vii. 231*b*. The most complete is the first in the *Physica*. Things are said to be successive, contiguous, or continuous.

> A thing is "in succession" when it is after the beginning in position or in form or in some other respect in which it is definitely so regarded, and when further there is nothing of the *same* kind as itself between it and that to which it is in succession . . . . (there is nothing to prevent something of a *different* kind being between). For that which is in succession is in succession to a particular thing, and is something posterior: For one is not "in succession" to two, nor the first day of the month to the second: In each case the latter is "in succession" to the former.[58]

There are thus two factors in the definition, i.e., order and direction, or sense. There is a similarity between this relation and a serial relation as defined for example by Bertrand Russell:

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[58] *Physica* 226*b*.

> A relation is said to be *serial*, or to generate a series, when it possesses three different properties, namely (1) being contained in diversity, (2) transitiveness, (3) connexity, i.e. the property that the relation or its converse holds between any two different members of its field.[59]

> A thing that is in succession and touches is "contiguous." The "continuous" is a subdivision of the contiguous: things are called continuous when the touching limits of each become one and the same and are, as the word implies, contained in each other: continuity is impossible if these extremities are two.[60]

There is the same sort of similarity between this definition of continuity and Russell's definition of a compact series: "A *compact* series is one in which there is a term between any two."[61] A more complete statement concerning continuity is given by Huntington.[62] His discussion applies definitely to the class of points on a line, or to the class of all instants of time arranged in order of priority. The Aristotelian definition includes three factors; for anything to be continuous it is necessary that the parts be homogeneous, that the direction once assumed be constant, and that the extremities of the parts not only touch but be one.

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[59] Whitehead and Russell, *Principia mathematica* (1st ed.), II, 513. By permission of the Cambridge University Press (New York: Macmillan Co.).

[60] *Physica* 227*a*.

[61] From Whitehead and Russell, *op. cit.*, III, 179.

[62] *The Continuum*, pp. 10–13, 16, 44–45.

Aristotle went on to point out certain things which follow from this definition of continuity It is impossible that anything continuous should be composed of indivisibles, for an indivisible has no extremities, and therefore its extremities can neither touch nor be one, both of which are necessary for continuity. Therefore, the continuous is always divisible into divisibles. This is true of magnitude (space), time, and motion. So much for the one part of the definition.

The other part is that quantity is divisible into parts each of which is by nature a "one." It must then be determined what a one is. Aristotle gave a definition of one.

> "One," then, has all these meanings—the naturally continuous, the whole, the individual, and the universal. And all these are one because in some cases the movement, in others the thought or the formula, is indivisible.[63]

These are different meanings. "One" sometimes means one thing, sometimes another.

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[63] *Metaphysica* 1052*a*. 34–36.

> "To be one" means "to be indivisible (being essentially a this and capable of existing apart) either in place or in form or thought" or perhaps "to be whole and indivisible" but it means especially "*to be the first measure of a kind*," and above all of quantity. . . . . For measure is that by which quantity is known; and quantity *qua* quantity is known either by a "one" or by a number, and all number is known by a "one." Therefore, all quantity *qua* quantity is known by the "one" and that by which quantities are primarily known is the one itself; and so the one is the starting point of number *qua* number. And hence in the other classes too "measure" means that by which each is first known, and the measure of each is a unit. . . . . In all these, then, the measure and the starting point is something one and indivisible, since even in lines we treat as indivisible the line a foot long. . . . . Now where it is thought impossible to take away or to add, there the measure is exact. Hence that of number is most exact, for we posit the unit as absolutely indivisible.[64]

In the case of magnitude it is not true, of course, that the unit can be considered as absolutely indivisible; but it is such that there is in a sense a whole—it possesses a natural unity.

At the close of a chapter on continuity, Mr. Bertrand Russell states that the definitions of Dedekind and Cantor

> do not correspond very closely to the vague idea which is associated with the word in the mind of the man of the

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[64] *Ibid.* 15–35.

> street or the philosopher. They conceive continuity rather as the absence of separateness, the sort of general obliteration of distinction which characterizes a thick fog, ... declaring it very truly, to be characteristic of his mental life and of that of children and animals.[65]

Mr. Russell points out that in the series of real numbers, each is what it is, quite definitely and uncompromisingly; it is a hard, separate unit and its distance from every other unit is finite, although it may be made less than any given amount assigned in advance. This mathematical continuity is, however, in his opinion, in a very definite relation to continuity as observed—that is, the continuity which is noted as applicable to time and space.

It would be absurd, of course, to maintain that Aristotle's discussion contained more than perhaps the merest germ of the idea of modern mathematical continuity. It should be pointed out, however, that the account in the *Physica* and the *Metaphysica* is neither foggy nor vague —in fact, that it does not square very well with the account which Mr. Russell attributes to philosophers. It is, on the contrary, quite definite, and the terms in it are definite (else he could never have drawn so clear a distinction between succession, contiguity, and continuity), since they are such as to be by nature a "one" and a "this," and his definition, as was shown above, corresponds surprisingly well to Mr. Russell's own definition and other modern mathematical discussions.

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[65] *Introduction to Mathematical Philosophy* (1919), p. 105. By permission of George Allen & Unwin, Ltd., publishers (New York: Macmillan Co.).

The definition of continuity with which the Aristotelian one has been compared is that based on the one of Dedekind and Cantor. It should be noted that the adequacy of this sort of definition was questioned by C. S. Peirce, who criticized the statement that refers to every point on a line, both because we cannot give definite meaning to the term, every point, and also because it is assumed in certain discussions, as of Zeno's paradoxes, that this definition is applicable to existent lines. "Personally, I agree entirely with James against Dedekind's view; and hold that there would be no actually existent points in an existent continuum, and that if a point were placed in that continuum it would constitute a breech of continuity."[66] He also called the Dedekind-Cantor type of definition a definition of a pseudo-continuum in contrast with true continuity, which we directly perceive in consciousness, and which he defined. This fundamental continuity is dependent on the temporal aspect of consciousness.

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[66] C. S. Peirce, *Collected Papers*, VI, 182; see also VI, 176. Reprinted by permission of Harvard University Press.

> [*Continuous* means] in mathematics and philosophy a connection of points (or of other elements) as intimate as that of the instants or points of an interval of time; thus, the *continuity* of space consists in this, that a point can move from any one position to any other so that at each instant it shall have a definite and distinct position in space.[67]

His own definition is as follows:

> The *material parts* of a thing or other object, *W*, that is composed of such parts, are whatever things are, firstly, each and every one of them, other than *W;* secondly, are all of some one internal nature (for example, are all places, or all times, or all spatial realities, or are all spiritual realities, or are all ideas, or are all characters, or are all relations, or are all external representations, etc.); thirdly, form together a collection of objects in which no one occurs twice over and, fourthly, are such that the Being of each of them together with the modes of connexion between all sub-collections of them, constitute the being of *W*.[68]

In an earlier discussion Peirce suggested that a combination of the Kantian and Aristotelian definitions would give a satisfactory definition of continuity.[69] Thus he seemed to find the

[67] *Ibid.*, p. 164.

[68] *Ibid.*, p. 174.

[69] *Ibid.*, pp. 122–23.

same definiteness in Aristotle's statements that has been discussed above, although he differed as to the proper definition of continuity, and perhaps gave a definition more directly based on experience.

There are a few points implied in Aristotle's discussion which might well be summarized here. His chief emphasis was on the continuous as opposed to the epochal view of time; but since it is a continuous quantity which is divisible into natural units, his definition does not neglect entirely the epochal aspect. The same recognition of the dual character appears also in another phase of his discussion. In the *Physica* Aristotle showed that, as continuous, magnitude (space), motion, and time are potentially infinitely divisible. This is much the same thing as saying that, considered as highly abstract (under a high degree of abstraction), time may be treated as if it had this undifferentiated sort of continuity. But, considered concretely, this is not possible; for, as Aristotle pointed out, this infinite division is a matter of potentiality, not of actuality. It is when we consider concrete becoming, that the natural units appear. The use of the term "number" also suggests a recognition of the atomic character. In fact, this term was noted by Strato of Lampsicus as a criticism of Aristotle. Strato "does not admit time to be the number of motion because number is discrete quantity, but motion and time are continued and the continued is not numerable."[70] To this objection Simplicius answered, Aristotle "calls time number; not that it is simply number, for he shows time is continued, as well as magnitude and motion; but as bounded by the distinction of prior and posterior in its continuity, by those who are capable of perceiving time."[71] A more fitting answer might be that in his definition of time Aristotle used now the term "number" and now the term "measure." Thus, although with some justice it may be said that the former term indicates that Aristotle recognized the epochal character of time, it does not show that he considered this to be its only character. Certainly it is clear from his general discussion that Aristotle emphasized the continuous character of time in distinction from the Platonic emphasis on the atomic.

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[70] Cf. Aristotle's *Works*, trans. T. Taylor, iv. 548; also Simplicius *op. cit.* 789.

[71] Aristotle's *Works*, trans. T. Taylor, iv. 548.

This emphasis on the continuous character of time is increasingly important in the Peripatetic school, as can be judged from Strato's criticism. While the commentators on Aristotle in general show Platonic influence, it is interesting to note that even when they directly compared the definitions of Plato and Aristotle, it is the Aristotelian emphasis on continuity which was of importance in their thoughts. A significant thing about this definition is the connection (yet not identification) of time and motion. This led to an emphasis on the physical and objective aspect of time as opposed to the general tendency of both other definitions discussed. As such it placed greater emphasis on the measurable character of time, although without a detailed discussion of this possibility. It should also be noted that Aristotle gave a rather peculiar discussion of certain points because of his aim, not to describe some character of nature which shall be called "time," but to analyze and clarify what the ordinary notion of time was. The question of its ultimate existence or reality played no part in his discussion. This, again, is in marked contrast with the Platonic tradition. Aristotle merely pointed out that whatever existence it had was of an unusual sort; for while it certainly exists in some sense, it does not exist in the same sense in which physical objects do. However, even with this objective emphasis we find also the suggestion that time is not independent of the mind—but this is a matter which Aristotle left a problem.

The Aristotelian definition recurred constantly. Among the scholastics the definition received only one significant modification. It was supplemented by the Platonic contrast between time and eternity, and to these two concepts was added a third, *aeorum*, midway between *tempus* and *aeternitas*. *Aeorum* pertained to beings which in essence are immutable, but which change according to accident, qualities, etc.; such as angels and human souls. Thus time became even more distinctly confined to the physical world.

The Aristotelian definition as taken over by the scholastics was not considered to be essentially realistic. In *La Notion du temps*, Nys pointed out a contrast between the Aristotelian or Thomist theory and either the ultra-realist or objective view or the ultra-idealist or subjective theory.

Au point de vue de l'objectivité, la théorie thomiste, a bon devit, le nom de réalisme modèrne. Le concept de temps représente une sorte d'être mixte, doué à la fois d'un caractère objectif et subjectif. Abstraite du movement continu, le temps possède assurément dans le mouvement, un être réel. Cependant, le mouvement n'est pas le temps et ne peut le devenir sans le concours de l'intelligence qui fractionne sa continuité et réunit dans un même tout les parties qu'elle y distingue. Puis dans sa totalité, ce concept désigne donc un être réel mais essentiallement fugitif, le présent, et ses éléments qui n'ont comme tels qu'une réalité idéale, savoir, le futur, et le passé. De là, son caractère objectif et subjectif.

En résumé, la caractère essentiel de la théorie scolastique consiste dans l'identification de l'être réel du temps et du mouvement continu, ou, si l'en veut, dans la négation de toute distinction réele entre l'un et l'autre.[72]

SUMMARY OF THE PROBLEMS RAISED BY THE GREEKS AND THEIR MEDIEVAL SUCCESSORS

It seems valuable to insert here some summary of the problems involved before going on with the discussion of the development within the modern period. It is impossible to draw any hard-and-fast temporal line, but the views discussed thus far clearly contain nothing more than the natural amplification of Greek thought. With one exception they fall within the ancient or medieval periods. That exception—neo-scholasticism—was included in this chapter because it added little to the Aristotelian definition except some consideration of the changed scientific position and of measurement. These did not essentially modify the definition of time. Other modern discussions will be dealt with in separate sections since they demand a different basis of classification because of new scientific problems, increased complexities, and new philosophical theories. It is true, of course, that many names which one might have expected to find have been omitted in the periods already discussed. But the selection was made in such a way as to include the main ideas concerning time which were present during the period.

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[72] Pp. 205–6.

Turning, then, to a summary of the problems that have been discussed, there is to be noted first a very general recognition that there exists some relation between time and motion or change. The emphasis upon the importance and meaning of this relation varies from those who identified time and motion[73] to those who minimized the importance of the relation and defined time as "the interval of motion or rest." On the whole, a middle position was taken: time is not motion but is closely related to it, so that time cannot exist in independence of motion. Into these discussions there usually was brought the idea that motion and the "calm rest of things" can exist only in relation the one to the other. The full significance of the relation of time and motion is only suggested by the statement that time depends on motion or is the number of motion. Perhaps the relation is less clear than it might have been had more stress been laid on the problem of the measurement of time. There is, during this period, the opposite tendency—to make motion dependent on time. This is a much less influential idea, and never given even as full discussion as the other received.

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[73] Cf. Aristotle *Physica* iv.

Another problem which appeared as fundamental was the relation between the continuous and epochal aspect of time. These often appeared as contradictory concepts, and there were all varieties of opinion, from the Atomists who admitted only its epochal character to Zeno whose paradoxes arise, in part at least, from thinking only of its continuity. Also the view of Hippocrates involved only the idea of continuity, but was a more concrete concept than that of Zeno. It is worth noting that the men who might be said to have a dominant scientific interest were those who referred to only one of these two characters. Aristotle and Plato, on the other hand, admit both factors with a difference in emphasis largely due to their methods. This becomes clearer if the relation between the continuity or atomicity of time and the value of the concept as an ultimate category is considered. Time was not an important conception for Plato. It is the imperfect image of that which is itself unity. The important thing about it is that quality by which it reflects eternity; that quality is expressed in its character as epochal. There is in this character at least some degree of completion. Aristotle placed the greater value on continuity.

> Now "being" . . . . is better than "non-being"; but not all things can possess "being" since they are too far removed from the "originative source." God therefore adopted the remaining alternative, and fulfilled the perfection of the universe by making coming-to-be uninterrupted; for the greatest possible coherence would thus be secured to existence, because that "coming-to-be should itself come-to-be perpetually" is the closest approximation to eternal being.[74]

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[74] Aristotle *De generatione et corruptione* ii. 10. 336*b*.

Thus it is with much the same motive that Plato stressed the atomic and Aristotle the continuous character of time.

As has already been suggested, the problem of measurement seems to have been formulated less clearly by the Greeks than any of the other problems relating to time, unless it be that of subjectivity or objectivity. There probably is some connection between these two problems. For example, in the one place in which Aristotle suggested the possibility of time being subjective, he raised this problem as an outgrowth of its quality as numerable. The neglect of measurement may be due to the Greek failure to draw clear distinction between the subjective and the objective. It may also have been in part a product of the idea of harmony so essential in the theories of the Pythagoreans and of Plato—the idea of the fitting of things, that simple mathematical relations govern the natural world. As will be shown later, the idea of fitting furnishes an adequate basis for measurement, and if this idea is the basis for one's metaphysics, no problem about measurement will arise. There is further evidence for the relation of subjectivity and measurement in the comparatively full discussion of measurement given by Augustine, which occurs not only in connection with, but as obviously dependent on, a decidedly subjective view.

The Greeks also raised the problem of the reality and importance of time in the natural world, but this was not given very full discussion.

We are left, then, at the beginning of the modern period with one rather certain conclusion, namely, that there is some relation between time and change or motion. It also seems probable that the idea of time should involve both continuity and atomicity; at least these did not seem completely contradictory in the theories of Plato and Aristotle, although their relative importance is uncertain.

CHAPTER III

THE MODERN PERIOD TO THE MIDDLE OF THE NINETEENTH CENTURY

THE NEWTONIAN CONCEPT

In the discussion of the modern period one is forced, by the mass of material, to omit even more of importance than has been done in the earlier periods. The attempt has been to cite outstanding men who offered typical or influential conclusions or who introduced new problems concerning time, and thus to bring together the ideas on this subject that were prevalent in the middle of the nineteenth century. There seem to have been three sciences which have contributed to a considerable degree to the idea of time: physics, biology, and psychology. These, with what might be called the strictly philosophical treatments, constitute four threads whose interweaving is traced from the beginnings of the modern period up to the present. Because of the increased emphasis on the importance of time, the new and complicated problems arising in connection with it, and the consequent mass of material in the

145742

twentieth century, most of the discussions after 1850 are treated in a separate chapter.

The development of a new world-scheme in revolt from the Aristotelio-medieval system brought with it a changed emphasis in the discussions of time. Nicholas Cusanus[1] continued to stress the contrast between time and eternity as was done earlier, but also made certain statements which suggest changes in the concept of time. He emphasized the difference between absoluteness and relativity and applied this to the question of the divisibility of space and time. In our thoughts there is no point at which the division of things becomes impossible, but actually we reach a point at which division can no longer take place. This point would be the atom, if it is matter which is divided; the instant, if it is time. Similarly, while continuous motion is thinkable, it is actually impossible. This at least suggests one solution to the problem of the continuity or atomicity of time. Cusanus did no more than suggest this. He also discussed the problem of absolute or relative motion, and pointed out that absolute motion depends on there being an absolute center of the universe, for only such a center could be at rest. We conceive of the world as such a center and at rest merely because it is our point of observation. As this is merely an arbitrary matter, absolute motion is impossible. It is clear how suggestive this is of the new world-scheme—and also the change that it logically implies in any of the earlier definitions which had made time in some way dependent on motion.

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[1] Cf. H. Höffding, *History of Modern Philosophy* (1900).

Carrying out the idea of the relativity of motion, there is next the Copernican theory. The suggestion for this was the discovery by Copernicus that the ancient philosophers were not in agreement as to the proper center of reference for the motion of heavenly bodies. Following out this idea, he found that a much simpler explanation of the motion of the heavenly bodies resulted from taking the sun rather than the earth as the resting center of reference. He offered this not on the grounds of empirical truth but on the grounds of simplicity or rationality.[2] In Copernicus, as earlier in Cusanus and later in Bruno, this was part of the revived interest in mathematics and the view that number has a metaphysical significance. This is important, because such a mathe-

[2] Cf. *De revolutionibus*, Letter to Pope Paul III.

matical theory of nature furnishes a basis for a theory of measurement. The ideas of Cusanus and Copernicus were developed by Giordano Bruno in such a way as to show their full significance for the idea of time. From the idea of the relativity of motion he proved the relativity of time; for since no absolutely regular motion can be discovered, we can have no absolute measure of time. In these three thinkers it is clear that the modern period took over the idea of the essential relation of motion and time. This is indeed characteristic of the entire modern scientific development, and is if anything even more evident in the twentieth-century discussions than it was earlier.

Copernicus had sensed the relativity of our measurements, but Bruno was the first to carry this principle to its logical conclusion. How fully he did this is evident in the very significant statement which Höffding makes about him, which would indicate that he reached a completely relative concept as far as time is concerned. "Since motion appears different when regarded from different stars, there must, if it is to be taken as the measure of time, be as many times in the universe as there are stars."[3]

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[3] *Op. cit.*, p. 125. By permission of Macmillan & Co., Ltd., publishers (New York: Macmillan Co.).

This was accompanied, however, in Bruno's general world-view by a belief that nature is everywhere the same. He was led to take this position by the experience of discovering that Vesuvius, which from the hill Cicala had appeared in the distance low and barren by contrast, when approached was high and wooded, while Cicala appeared barren and unfruitful. This principle of indifference has played an important part in the development of science. From it comes the idea that there is a sense in which simultaneity may be conceived as extending throughout the universe. It involved the ideas of relatedness and order and thus became a basis for a theory of the measurement of time.[4] Another aspect of the theory of measurement was discussed by Bruno in his revival of atomism in the *De minimo*. The existence of the atom, or indivisible minimum, was held to be a prerequisite of measurement and, as knowledge was identified with measurement, it is also a necessity of knowledge. (This relationship between measurement and knowledge has been developed fully in the progress of science, but the supremacy of the measurable as an object of knowledge is being challenged today.) As the minimum or atom is the prerequisite of measurement, it differs in various fields. In the case of both time and space, Bruno sought to disprove their infinite divisibility and maintained that they consist of discrete parts. They are, however, infinite in extent, for the addition of discrete particles can be carried on indefinitely. It is interesting to find this atomic view of time in one whose views were so generally in line with the scientific advance, and to find it introduced as a necessary basis for the measurement which is so fundamental to science; but neither in the Greek nor in the modern period has there been any general acceptance by scientists of the atomic notion of time.

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[4] J. L. MacIntyre, *Giordano Bruno*, pp. 227 and 232, and Bruno, *De minimo*, p. 153.

Kepler further carried out the implications of the view that the existence in nature of quantitative relations was important for any scientific knowledge of the world. This became the foundation of all modern physical science. But the idea that the existence of atoms, or ultimate units of measurements, is necessary for any justification of measurement was forgotten. With Galileo there was a return to the idea of continuous space and time, though still with the stress on the existence of quantitative relationships. He was interested in questions of continuity which he discussed under the terms the infinitely small and the infinitely great, and in the paradoxes of measurement.[5]

This tendency crystallized in the famous definition of Newton. He confirmed the idea of Bruno that nature is everywhere similar, but he disregarded his idea of the necessity of a minimum for measurement. This is in line with the distinction on which he insisted between sensuous time and space and absolute time and space. The former are regarded as relative and as distances between things and events which we can sense and measure. The latter are necessitated if we are to give any definite meaning to real motion, that is, it must be thought of as taking place in absolute space and absolute time. He pointed out that in certain cases we are aware of absolute motion because of the effect it has on the body moved, as in the case of motion transmitted to a liquid in a revolving vessel, which is evident in the resulting concavity of the liquid. Thus we reach his famous definition of absolute time which is part of the framework for absolute motion and of relative time which we sense:

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[5] V. Vasiliev, *Space, Time, Motion*, p. 51.

> Absolute, true and mathematical time of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration; relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, and this which is commonly used instead of true time; such as an hour, a day, a month, a year.[6]

This may be taken as the accepted definition which was to dominate the conceptions of the natural sciences.

It is through the idea of absolute space and time as distinct from the relative or sensuous that we come to the idea of the essential relation of God and nature. Absolute space and time are said to be the sensorium of God in which events take place or which serves to unify them.

> He [God] is not eternity or infinity, but eternal and infinite; He is not durations and space, but he endures and is present. He endures forever and is everywhere present; and by existing always and everywhere, He constitutes duration and space.[7]

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[6] *Principia mathematica* (English trans. by Motte), Book I, scholium I.

[7] *Ibid.*, Book III, General Scholium.

This theological and religious interest which was so important for Newton did not continue to be influential in determining the thought of the natural sciences, but the idea of absolute time, defined as Newton defined it, flowing equably and independent of anything external, continued as a sort of metaphysical entity underlying our inaccurate measurements of time—a standard to which they may be said to approximate. The word "duration," which occurs as the equivalent of absolute time, requires some comment. It is in no way connected with the concrete passage of events or with development or life as it has later come to be (cf. Bergson). As far as any knowledge of it is concerned, it is just one dimension in an empty framework within which we measure relative motions in terms of relative space and time. There is no reference to the importance of its direction, or any effect of cumulation due to its passing. These, if they are to be asserted, are true of the finite events filling the frame rather than any character of time itself.

From the scholia quoted, and also from the general treatment of the time factor throughout the *Principia*, it appears that time for Newton was continuous; there is, in fact, no suggestion that it could be considered in any other way. It is objective, for all possible arguments for considering it subjective are answered by referring them to sensuous time in which there is admittedly a subjective factor. Absolute time is only approximately measurable, and that is by reference to motion. In the later stages of physics the approximate character of the measurements was at least temporarily neglected.

In many respects the Newtonian definition reminds one of Aristotle's discussion, and also of the more scientific views among the Greeks —for example, Zeno's. The Aristotelian emphasis on continuity has become marked to the point of excluding all other considerations. The connection with motion and change is still marked, although it has become less fundamental. Duration, as a mode of God's existence, is real, while for Aristotle the reality of time depended on its relation to motion. In neither of them does the passage of time seem to make any real difference. This idea was, however, inherent in the actualization of possibilities on which the Aristotelian metaphysics was built; it is contrary to the religious position of Newton with its insistence on the eternal nature of God the ultimate reality; and consequently the idea of time had little concrete meaning. This continued to be true in physics and the thought developing from it long after the theological basis had been given up.

THE EARLY PHILOSOPHICAL DISCUSSIONS

A more strictly philosophical discussion of time is that offered by Descartes. He preceded Newton, and his philosophy was part of that earlier gradually changing world-view which led to the mathematical-mechanical conception. But while certain aspects of his philosophy were in line with the development just discussed, his definition of time is of a quite different sort and was, therefore, omitted until after the discussion of Newton's definition. Time was not a fundamental concept in Descartes's philosophy; it was, in fact, rather glossed over in his discussion of the external world, and is never treated in a thoroughly unambiguous fashion.

The fundamental concept of Descartes's philosophy is that of substance. Here he adopted the scholastic idea that the substance, essence, and conception are all identical, so that what is not essential to the conception of a thing is not essential to its existence. In the case of the two created substances, mind and matter, there is in each case only one attribute, thought and extension, respectively. It must be borne in mind that these substances are independent of each other. Therefore, in trying to see how the concept of time was developed by Descartes, first one substance and then the other must be discussed. In the case of matter, as extension is its only attribute, the question of existence should be merely, "Is it extended?" This, were he consistent, is the only test Descartes should use. But he slipped in another, and that quite without explanation. This other is endurance, which brings in the temporal quality. If, then, endurance as well as extension is a characteristic of the existence of material things, one must say that it is also an attribute of extended substance or that time is an attribute of substance. Descartes never explicitly did this, so that no statement can be made on this basis as to whether Descartes considered time an attribute of reality. But in connection with his discussion of the continued existence of the self, or finite mental substance, there is some indication of the nature of time, and this could also be applied to the endurance of finite material substance. He stated that our lives are divisible into an infinite number of parts because time is itself atomic or made up of discrete instants. This statement in itself presents a problem. Can one say that the duration of my life, which is a finite quantity, is divisible into an infinite number of parts without asserting that it is continuous? It is worth noting that Regis said that our lives are divisible into a great number of parts, which may be what Descartes meant. It might also be that time as infinite quantity is divisible into an infinite number of discrete parts, although the life of any finite self is not. It has been questioned whether these statements really indicate that Descartes held an atomic view of time since Descartes's idea of permanent substance implies a continuous time.[8] But this view of time as continuous does not function either in Descartes's discussion of the finite self or of physical objects. Whatever the solution of the difficulty, as far as created substance is concerned, Descartes's discussion suggests the atomic view of time, and in general there is scant justice done to the idea that it is continuous.

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[8] A. Boyce Gibson, *The Philosophy of Descartes*, p. 127.

Another difficulty arises in his treatment of motion.[9] If one is concerned with his metaphysical writings, one finds motion treated as it were geometrically, as change in position, the emphasis being on the change in position not on the process.[10] On this view motion is merely a mode of the attribute of extension, and if time is to depend on motion, as it so often does, time must be given a very minor rôle in existence. On the other hand, in his more strictly physical writings motion is really conceived as a third substance, like matter in being unconscious, like mind in being unextended and active. Motion really, as well as matter and mind, is dependent for its being solely on the creative power of God. The difficulty here was not escaped by those followers of Descartes who laid more consistent emphasis on occasionalism. Descartes's discussion gives, at best, a confused notion of the relations between time, motion, extension, and God.

MATTER	MOTION	MIND
Extended	Unextended	Unextended
Unconscious	Unconscious	Conscious
Passive	Active	Active

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[9] Cf. N. K. Smith, *Studies in the Cartesian Philosophy*, pp. 67 ff.

[10] This is exactly the sort of treatment we found in his contemporary physicists, and effective in the Newtonian conception.

So far, although one reference was made to the self, the discussion might have been confined to what Descartes said of extension. Here the word which Descartes used is or should be duration, not time, whereas time is the word used concerning the self. In order to show how time is involved in mind, several quotations seem desirable.

> We will also have most distinct conceptions of duration, order and number, if, in place of mixing up with them that which properly belongs to the concept of substance, we merely think that the duration of a thing is a mode under which we conceive this thing in so far as it continues to exist. . . . .[11] Thus, for example, time, which we distinguish from duration taken in its generality, and call the measure of motion[12] is only a certain mode under which we think duration itself; for we do not indeed conceive the duration of things that are moved to be different from the duration of things that are not moved. . . . But that we may comprehend the duration of all things under a common measure, we compare the duration of the greatest and most regular motions that give rise to years and days, and which we call time; hence what is designated is nothing superadded to duration, taken in its generality, but is a mode of thinking.[13]

[11] *Principles of Philosophy*, Part I, principle lv.

[12] Note reference to the Aristotelian definition.

[13] *Op. cit.*, Part I, principle lvii.

It is clear from the foregoing definitions that Descartes made a type of distinction which we have already noted in the earlier period and which is also analogous to Newton's distinction between absolute and sensuous time, although absolute time differed in certain respects from duration as the term is employed by Descartes. Duration does not involve measure, and is clearly distinguished from time, which does and which is merely a mode of thinking. Time in one sense belongs to the same class as all the other modes, substance can be conceived without it although it cannot be conceived without substance; thus time is distinguished from the attributes. Time, however, is a degree further from reality; for while duration is a mode of extension, time is merely a mode of thought about extension. This brings up the question, which was never satisfactorily answered by Descartes, as to the relation between a mode of thought and a mode of extension.

It should be noted in concluding this discussion that Descartes treated time less well than most other concepts. Still, even in this case he managed to indicate most of the important considerations, although in a rather confused form. Thus he recognized both the atomic and the continuous aspects of time; its relation to motion; its relation to thought; the distinction between duration and measured time. (Here, as was noted also with Newton, duration does not have the full meaning it took on later.) All these conceptions are brought up by Descartes, not very explicitly in some cases it is true, but they are at least suggested. On the other hand, no detailed theory about any one of them is completed.

One might suggest in passing that there seems to be a relation between Descartes's use of the term "extension" and Professor Whitehead's use of the term "extensity"; that in placing extension and endurance at the basis of substance, Descartes had the idea of an extensity which was differentiated into temporality and spatiality.

Spinoza's treatment of time is very clearly a development of the philosophical treatment so general in the Middle Ages and as such might have found a place earlier in this essay. His emphasis is so exclusively on eternity that it is hard to feel that he gave an adequate place to time. According to Spinoza, the term "body" refers definitely to three-dimensional quantity which is determined by a limiting figure. But these are not qualities applicable to extended substance (extension or space); that is not composed of parts but is infinite and continuous. If Spinoza had treated time or measured duration in a similar fashion, he would have found an attribute of substance, duration, to which all durations might be resolved, and which would differ from definite measurable durations in that it is not made up of parts, is continuous, and is infinite.[14] Spinoza, on the contrary, always discussed duration as related not to a single time or duration but to eternity, and that is never given a place on a par with extension as an attribute of substance. Turning to what Spinoza definitely said concerning time, one finds: "Duration is the indefinite continuance of existing."[15] Duration pertains to particular things which exist, and it pertains to them not in so far as they are involved in the attributes of God but in so far as they actually exist or continue. Time as a definite, and measurable (if not actually measured) continuance is a product of the imagination.

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[14] Cf. S. Alexander, *Spinoza and Time*, *passim*.

[15] *Ethics*, Part II, def. v (trans. Elwes, II, 82).

> Further no one doubts that we imagine time, from the fact that we imagine bodies to be moved some more slowly than others, some more quickly, some at equal speed.[16] . . . . It is in the nature of reason to perceive things under a certain form of eternity. *Proof*. . . . . We may add that the bases of reason are the notions which answer to things common to all and which do not answer to the essence of any particular thing; which must therefore be conceived without any relation to time, under a certain form of eternity.[17]

The preceding quotations are sufficient to indicate three things: (1) Spinoza drew the distinction, which we have noted before, between indefinite duration and time. (2) Time is dependent on motion. (3) This is true not only of time as measured but also of indefinite duration. However, it is not only the measured aspect of time which is contrasted with that which can be known according to reason but also the transient and changing character of things. Time is thus merely a quality of empirical existents.

If one considers next what Spinoza said about the Infinite Modes of Motion and Rest, one finds a corresponding overemphasis on the spatial character of Motion; so that one feels there is some justification for the statement that Spinoza conceived of motion statically and geometrically.[18] Thus, a consideration of what Spinoza wrote of time in his discussion of extension (i.e., in his philosophy of nature, and this is the only connection in which he did give it definite consideration) can hardly fail to lead to the conclusion that time, as a quality of our experience, does not have a real place in his system.

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[16] *Ibid.*, Prop. XLIV and note (Elwes, p. 116).

[17] *Ibid.*, Cor. II (Elwes, p. 117).

Much the same conclusions are pointed out by H. F. Hallet, based on the *Cogitata metaphysica* as well as on the *Ethics*.[19] In the former, Spinoza indicated that eternity is prior to duration, which in turn is prior to time; but that they are known in the reverse order. Duration is persistence and has a quantitative character, whence comes our idea of measured time. This is a relative idea reached only by comparison. Time is, then, not real but only a mental tool. There can be no absolute measure of duration, since no unit can be found. Still duration is essentially divided, owing to its irreversible, or assymetrical, character. Hence it cannot be real, for this would involve the contradiction of predicating change to God.[20] Hallet, however, interprets Spinoza in the following fashion: "The creativity of duration, therefore, is but a finite extract of real creativity which is eternal and constitutive."[21] While time is known only through the imagination, eternity cannot be so known, but is known by the intellect. This, however, is accomplished by reasoning from our knowledge of existing things. "In duration, therefore, we must find the clue to the concrete character of eternity."[22] It is difficult to understand creativity as applied to an essentially timeless substance. Nevertheless, since this is clearly part of Spinoza's thought, it should be considered. Thus, while the concept of eternity is the most important single concept in Spinoza's system, the concept of infinite creativity is also fundamental.

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[18] Smith, *op. cit.*, p. 154.

[19] "Spinoza's Conception of Eternity," *Mind*, XXXVII (N.S., 1928), 283–303.

> From God's supreme power, or infinite nature, an infinite number of things,—that is all things have necessarily flowed forth in an infinite number of ways, or always follow the same necessity. . . . . Wherefore the

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[20] Cf. Spinoza, *Cogitata metaphysica*, Part II, chap. i (trans. Britan, pp. 139–40).

[21] *Op. cit.*, p. 301.

[22] *Ibid.*, p. 303.

omnipotence of God has been displayed from all eternity, and will for all eternity remain in the same state of activity.[23]

Spinoza thus emphasized the activity of mind as constituting its characteristic perfection. This is not the same as saying that time is mental (Spinoza himself, as has been noted above, implied that it is imaginary and not rational); indeed, he did not mention time in this connection. It is true, however, that the static quality which seemed characteristic of the real as described in his philosophy of nature disappears in the philosophy of mind. Further, nature and mind are for Spinoza but two aspects of one substance which is creativity. It is not clear how these two views can be reconciled—at least they cannot be reconciled without going far from Spinoza—but Spinoza certainly did not have the idea of a dead substance which some people seem to read into his writings. It is true that the idea of activity seems in no way demanded by his general theory of substance; it is only if the modes are considered as an essential part of his system that the importance of activity appears. That which is essential to the nature of each particular thing is

[23] *Ethics*, Part I, Prop. XVII n. (Elwes, pp. 60–61).

its *conatus*, by which "everything, in so far as it is in itself, endeavours to persist in its own being."[24] The persistence is not the stability of death, but is rather the reverse side of creativity—a struggle to maintain its individuality in the flux of time. This is in a sense not consistent with Spinoza's emphasis on eternity; it is rather a concept which one might expect to find in a system whose main concept was a Heraclitean flux. Nevertheless, it should not be overlooked entirely in this context.

There is a rather similar notion concerning Leibniz' monads, whose individuality consists in their activity. And, like Spinoza's view, this activity or force does not seem to be accompanied by any very real progress. In this case it is due to the idea of pre-established harmony. Naturally this gave the concept of time a secondary place. Leibniz was also opposed to the Newtonian conception of absolute time.

> As for me, I have more than once stated that I hold *space* to be something purely relative, like time; space being an order of co-existence as time is an order of successions.[25] . . . . The parts of time and of space, taken

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[24] *Ibid.*, Part III, Prop. VI (Elwes, p. 136).

[25] *Correspondence with Clarke*, Third Letter, par. 4 (from *Philosophical Writings* trans. Mary Morris in Everyman's Library, p. 199). By permission of E. P. Dutton & Co.

> in themselves, are ideal things: thus they are perfectly alike, like two abstract units. But this is not the case with two concrete unities, nor with two actual times, nor with two occupied, that is to say truly actual, spaces.[26] . . . . Time, apart from things, is not an absolute existent, but an ideal thing.[27] . . . . The one and the other of these fundamentals [i.e., space and time] are certainly seen as ideal. How can a thing exist of which no part is ever in existence? For of time, nothing exists but certain moments, and a moment is not the same as a part of time. Whoever considers this observation will understand that time can be known only as an ideal thing.[28]

From these extracts it is clear that Leibniz did not treat time as an abstraction from the fundamental activity of the monads. Rather his discussion of time was intended to demonstrate the erroneous character of theNewtonian concept, which defined space and time as real entities. This view of space naturally involved the reality of material objects to which Leibniz' whole theory of monads as mental was opposed. Since he considered matter to be the result of our inadequate perceptions, it was natural that he should consider space and time as nothing in themselves, but as ideal constructions based on our perceptions of relations of coexistence and succession. With that starting-point, his idea of relational time followed inevitably. In the controversy with Clarke he pointed out that the Newtonian view involved the denial of the principle of sufficient reason on which all science depends. His argument also brings in the question of the identity of indiscernibles.

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[26] *Ibid.*, Fifth Letter, par. 27 (Morris, p. 215).

[27] *Leibniz an Bourgnet*, in Gerhardt, III, 595 (my translation).

[28] *Leibniz an die Churfürstin Sophie*, in *ibid.*, VII, 64 (my translation).

> The same is true of *time*. Suppose someone asks why God did not create everything a year sooner: and that the same person wants to infer from that that God did something for which He cannot possibly have had a reason why He did it thus rather than otherwise, we should reply that his inference would be true if time were something apart from temporal things, for it would be impossible that there should be reasons why things should have been applied to certain instants rather than to others, when their succession remained the same. But this itself proves that instants apart from things are nothing, and that they only consist in the successive order of things; and if this remains the same, the one of the two states (for instance that in which the creation was imagined to have occurred a year earlier) would be nowise different and not to be distinguished from the other which now exists.[29]

His relational view is that space and time are concepts derived from perceived relations among things which actually are mental. The sufficient reason for change in relation is always to be found in the nature of the whole world and derives ultimately, therefore, from the original choice of God. As has been suggested, this relational view as Leibniz set it forth does not make time, or the relation of succession, a very important concept because of his idea of preestablished harmony. But his derivation of time from the concrete events might otherwise have led to a view which made time or successive development more important than that which results from the Newtonian conception. This aspect of the relational view was not to be developed fully until the nineteenth and twentieth centuries.

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[29] *Op. cit.*, Third Letter, par. 6 (Morris, p. 200).

THE PSYCHOLOGICAL APPROACH

Leibniz' controversy with Clarke on the subject of time occurred later than the work of Locke, who is to be discussed next. Locke held to the Newtonian view, but there is this similarity to Leibniz, that he was concerned even more exclusively with our perceptions and the resulting conception of time and even less with the nature of time itself. According to Locke, we have a dual conception of time (and also of space). There is time, which is relative to human experience, and there is duration, which is independent. "First, Time in general is commonly taken for so much of infinite duration, as is measured out by and co-existent with the existence and motions of the great bodies of the universe, so far as we know anything of them."[30] He had shown that the idea of time in general is obtained in a legitimate way from the succession of ideas in our minds.

> And thus I think it is plain that from those two fountains of all knowledge before mentioned, [viz.] reflection and sensation, we get ideas of duration, and the measures of it.
>
> For, First, by observing what passes in our minds, how our ideas there in train constantly some vanish and others begin to appear, we come by the idea of succession.
>
> Secondly. By observing a distance in the parts of this succession, we get the idea of duration.
>
> Thirdly. By sensation observing certain appearances at certain regular and seeming equidistant periods, we get the ideas of certain lengths or measures of duration, as minutes, hours, days, years, etc.
>
> Fourthly. By being able to repeat those measures of time, or ideas of stated length of duration in our minds, as often as we will we can come to imagine duration where nothing does really endure or exist: and thus we imagine tomorrow, next year, or seven years hence.

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[30] *Essay on Human Understanding*, Book II, chap. xv, par. 6.

> Fifthly. By being able to repeat ideas of any length of time, as of a minute, a year, or an age, as often as we will in our own thoughts, and add them one to another, without ever coming to the end of such addition, any nearer than we can come to the idea of eternity, as the future eternal duration of our souls, as well as the eternity of that infinite Being, which must necessarily have always existed.
>
> Sixthly. By considering any part of an infinite duration, as set out by periodical measures, so we come by the idea of what we call "time" in general.[31]

It is clear from this quotation that Locke was concerned chiefly with explaining how we reach the idea of time and that this idea is derived from the succession of sensations; that is to say, the idea of time is dependent on there being changing sensations in our consciousness. Locke was aware that this explanation gave us no idea of exact measurement of time; in fact, he pointed out that the measurement of time was both relative and arbitrary. "No two parts of time can be certainly known to be equal."[32] Time as measured in this arbitrary way is not to be confused with duration. The relation between this view and Newton's sensuous and absolute time is evident. "Duration,

[31] *Ibid.*, chap. xiv, par. 32.

[32] *Ibid.*, par. 21.

in itself, is to be considered as going on in one constant, equal, uniform course. But none of the measures of it which we make use of can be known to do so."[33] Since our objective measures of duration are uncertain, Locke suggested falling back on a subjective measure of time—that is, the number of ideas passing through the mind, which he thought would not vary so very much for a waking man.

This empirical and subjective line of reasoning was carried out by Berkeley, but with this difference in the conclusions, as one would naturally expect, that there is no consideration of duration as different from the experienced succession of ideas.

> For my own part, whenever I attempt to frame a simple idea of *time*, abstracted from the succession of ideas in my mind, which flows uniformly, and is participated in by all beings, I am lost and embrangled in inextricable difficulties. I have no notion of it at all, only I hear others say, it is infinitely divisible, and speak of it in such a manner as leads me to harbour odd thoughts of my existence; since that doctrine lays one under the absolute necessity of thinking, either that he passes away innumerable ages without a thought, or else that he is annihilated every moment of his life; both which seem equally absurd. Time therefore being nothing abstracted from the succession of ideas in our minds, it follows that

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[33] *Ibid.*

> the duration of any finite spirit must be estimated by the number of ideas or actions succeeding each other in that spirit or mind.[34]

Thus in connection with time, as well as in his general metaphysics, Berkeley escaped any bifurcation by the device of entire subjectivity. Time, then, is an entirely relative matter, perhaps varying from individual to individual in its measurable aspects; at any rate, each of us would appear to have his own time, shut up as we are to the succession of our ideas. In that case there would be no problem of measurement, or rather there would be no measurement in any of the usual senses of that word. We might, of course, make certain postulates, but the equations based on these would have no objective or universal meaning. Berkeley, of course, did not reach this conclusion, but brought in the conception of God to furnish the standard of reference which is necessary for even relative measures. Thus my ideas of time are correct in so far as they correspond to the succession of ideas in God's mind. There is this to be noted about Berkeley's discussion of time: he treated it throughout as dependent on concrete events, though subjective. This is important because of later developments.

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[34] George Berkeley, *A Treatise concerning the Principles of Human Knowledge*, principle 98.

Hume also carried on the treatment suggested by Locke, but with the skeptical results that characterized all his views. His conclusions may be briefly stated in his own words:

> 'Tis evident that time or duration consists of different parts: For otherwise we could not conceive a longer or a shorter duration. 'Tis also evident, that these parts are not co-existent; for that quality of the co-existence of parts belongs to extension, and is what distinguishes it from duration. Now as time is composed of parts that are not co-existent, an unchangeable object, since it produces none but co-existent impressions, produces none that can give us the idea of time; and, consequently, that idea must be derived from a succession of changeable objects, and time in its first appearance can never be severed from such a succession.[35] . . . . Time is not infinitely divisible.[36]

It appears that Hume continued to connect time with concrete events, but as he had elsewhere proved that we can have no objective knowledge, only knowledge of momentary sensations, this concept of time does not seem very significant. It is interesting to note that he did not consider time to be continuous. This was an unusual idea at that time, but one which usually develops only when time is derived from concrete events, particularly when it is also connected with a subjective view. Considering the skeptical nature of Hume's conclusion, it is not surprising that after him there was a change in the discussions of time, not only among philosophical discussions but also among those of psychologists who took up the investigation of our perceptions of time.

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[35] David Hume, *Treatise on Human Nature*, Book I, Part II, sec. 3.

[36] *Ibid.*, sec. 2.

THE KANTIAN DEFINITION AND ITS DEVELOPMENT

The next important development in the concept of time was that introduced by Immanuel Kant. There were two aspects to his thought in this connection—the physical and the critical. The former was not original. His earlier physical writings (*Gedanken über die wahre Schätzung der lebendigen Kräfte* [1747]; *Allgemeine Naturgeschichte und Theorie des Himmels* [1755]) show the Newtonian view of absolute space and time. In 1756 he tried to reconcile the Newtonian and Leibnizian views (*Monadologia physica*). Then, under the influence of the Leibniz-Wolff philosophy he adopted the relational view (*Neue Lehrbegriffe der Bewegung und* *der Ruhe* [1757]). By 1763 he was again defending the Newtonian view of space and time (*Versuch den Begriff der negativen Grössen in die Weltweisheit eingeführen*), and this view remained dominant in his consideration of physical problems (*Metaphysische Anfangsgründen der Naturwissenschäften* [1786]). It was, however, essentially modified by the development of his critical philosophy. His critical views of time appeared in several places in the *Kritik der reinen Vernunft* and present several contradictions. However, certain things are clear. Kant was concerned with indicating the contradictory character of time (and space) if it is considered either as an objective reality, an actually existing thing (Newton), or as a relation between such things (Leibniz). He indicated that these contradictions disappear if it is recognized as one of the forms of intuition, or as the form of the inner sense. That is to say, the various characters which time manifests can be understood if it is seen to be, not a thing experienced, but a condition of all our experience as a source of knowledge about phenomena. To this view he gave a lengthy exposition in the *Transcendental Aesthetic*. Time is not an empirical concept derived from experience, but, as a condition of experience, it is given *a priori*. It has only one dimension; different times are parts of one time. It is infinite in the sense that it is an unlimited form, a type of order. In the *Aesthetic*, Kant dealt with space and time in much the same way; but in the *Analytic*, he made time central since the proof of the categories depends on the consciousness of time.

In his *Commentary to Kant's Critique of Pure Reason*, Professor Norman Kemp Smith points out certain of the weaknesses in Kant's theory of time.

> It [Kant's doctrine of time] is the most vulnerable tenet in his whole system. A mere list of the points which Kant leaves unsettled suffices to show how greatly he was troubled in his own mind by the problems to which it gives rise. (1) The nature of the *a priori* knowledge which time yields. Kant ascribes to this source sometimes only the two axioms in regard to time, sometimes pure mechanics, and sometimes also arithmetic. (2) Whether time only allows of, or whether it demands representation through space. Sometimes Kant makes one assertion, sometimes the other. (3) Whether it is possible to apprehend the coexistent without successive synthesis of its parts. This possibility is asserted in the *Aesthetics* and *Dialectic*, denied in the *Analytic*. (4) Whether simultaneity is a mode of time. (5) Whether, and in

> what manner, appearances of the outer sense are in time. Kant's answer to 4 and 5 varies according as he identifies or distinguishes representations and empirical objects.[37]

But with these manifold difficulties in his detailed view, the general position is both clear, important, and original. Time is the work of the mind, a "schema" of connections making possible perception. It is "transcendentally ideal" although "empirically real." Thus Kant's theory would seem not to affect the physicist's conception. As has been indicated, Kant himself proposed it in connection with the general Newtonian view; it is interesting to note, however, that many relativists now find Kant's theory consistent with relativity or even demanded by it.

The influence of this critical view of time is generally apparent in the philosophical discussions since Kant. Schopenhauer seems closer to Kant's actual discussion than others of his immediate followers. He stated his main thesis on the subject:

> Whoever has recognized the form of the principle of sufficient reason, which appears in pure time as such, and on which all counting and arithmetical calculation rests,

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[37] *Commentary to Kant's Critique of Pure Reason* (1918), p. 137. By permission of Macmillan & Co., Ltd. publishers (New York: Macmillan Co.).

> has completely mastered the nature of time. Time is nothing more than that form of the principle of sufficient reason and has no further significance. Succession is the form of the principle of sufficient reason in time, and succession is the whole nature of time.[38]

He differed from Kant in detail, but it is clear from this quotation that the essential conception of time is the same. In asserting that space and time are forms of one principle, he took a step toward a unification of the critical position.

He also stated twenty-eight *predicabilia* concerning time, which indicate that he really added no new elements to the idea of time, but has summarized general conclusions in regard to time and holds that these can be understood if time is considered a principle dependent on the nature of thought.

1. There is only *one* Time, and all different times are parts of it.
2. Different times are not simultaneous but successive.
3. Time cannot be thought away, but everything can be thought away from it.
4. Time has three divisions: the past, the present, and the future, which constitute two directions and a centre of difference.

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[38] A. Schopenhauer, *The World as Will and Idea*, Book I, chap. i, p. 4 (Haldane and Kemp trans., I, 9). By permission of Kegan Paul, Trench, Trübner & Co., Ltd.

5. Time is infinitely divisible.
6. Time is homogeneous and a *Continuum*, i.e. no one of its parts is different from the rest nor separated from it by anything that is not time.
7. Time has no beginning and no end, but all beginning and end is in it.
8. By reason of time we count.
9. Rhythm is only in time.
10. We know the laws of time *a priori*.
11. Time can be perceived *a priori*, although only in the form of a line.
12. Time has no permanence, but passes away as soon as it is there.
13. Time never rests.
14. Everything that exists in time has duration.
15. Time has no duration, but all duration is in it, and is the persistence of what is permanent in contrast with its restless course.
16. All motion is only possible in time.
17. Velocity is, in equal spaces, in inverse proportion to the time.
18. Time is not measurable directly through itself, but only indirectly through motion, which is in space and time together; thus the motion of the sun and of the clock measure time.
19. Time is omnipresent. Every part of time is everywhere, i.e. in all space at once.
20. In time taken by itself everything would be in succession.
21. Time makes the change of accidents possible.
22. Every part of time contains all parts of matter.

23. Time is the *principium individuationis.*
24. The "now" has no duration.
25. Time in itself is empty and without properties.
26. Every moment is conditioned by the preceding moment, and is only because the latter has ceased to be. (Principle of sufficient reason of existence in time.)
27. Time makes arithmetic possible.
28. The simple element in arithmetic is unity.[39]

While not following Kant so definitely in his discussion of time, Fichte should be considered in the Kantian development. He attempted to do away with the dualism between noumena and phenomena, and thus with the distinction between the "transcendentally ideal" but "empirically real" nature of time. He seems to have come closer to giving time real significance than most philosophers of that period or of the nineteenth century. This is due to the nature of the ego, which seems to involve the idea of development in a temporal as well as a logical sense. The fact that the goal of progress is unattainable detracts but slightly, if at all, from the effectiveness of time in his system. This idea was not fully developed by Fichte, but is worth noting because of the great importance it attained during the nineteenth century and continues to maintain at present. Fichte may be viewed as being among those who foreshadowed this development.

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[39] *Ibid.*, Suppl. to Book I, chap. iv (Haldane and Kemp trans., II, 221 ff.).

With Hegel on the contrary, time was viewed solely in its formal character. He wrote much of evolution, but it is not an evolution involving temporal development but is purely logical. This is one of the factors which contributed to the intellectualistic tendency of Hegel and many of his followers. There is, of course, another side to Hegel's treatment which appeared in his idea of history. Here the concept of time is very important: History is the development of the Spirit in time as Nature is the development of Idea in space. The contrast between Spirit and Idea should be noted. The Idea develops without opposition, while Spirit is at war with itself. On this basis one could run a very nice interpretation of the contradictions in which one becomes involved in thinking about time, by showing that these contradictions are due to the warring of Spirit with itself. But any consideration of the Hegelian Absolute makes it clear that for Hegel time was not an ultimate characteristic; with him, the Absolute is a goal already attained, an idea quite contradictory to that of a real and effective time. Eternity is characteristic of the whole, although time and change may appear in a partial view. Much the same difficulty is encountered in trying to state the Hegelian view that was noted in connection with Spinoza. In his treatment of history and of the history of philosophy, it is clear that Hegel as well as Fichte was influential in turning man's attention toward development, and thus prepared the way for the acceptance of the idea of evolution.

THE EFFECT OF THE THEORY OF EVOLUTION

The increasing recognition of the importance of time as descriptive had scientific as well as philosophical sources. One was the contribution made by geology in extending time into the past. It is true that the Newtonian and some earlier definitions of time had dealt with it as infinite, but the extension of time was made a much more important factor in the concept by its becoming more concrete. This was probably due more to the development of geology than to any other one science, and among the important early works was Hutton's *Theory of Earth*. This involved the definite extension of an idea that has already been noted: "Nature is everywhere the same" to "Nature is always the same." His theory reached far into the past and also far into the future. It was founded on a minute as well as wide survey of present conditions and changes.

Not only did geological researches extend the idea of time, but by pointing out the great changes that have resulted from the summation of small forces they led to considering time as a more serious and influential factor in nature than would have resulted from the development of physics and the Newtonian conception of time. It is true that Newton considered time to be real, but its passage did not actually make any difference in things; it lacked that essential vitality which in the final analysis is our test for the real. The idea of essential development and time as making a difference to individual things had appeared in Hippocrates, and was implied in Aristotle's general metaphysics, but did not affect his definition of time; nor did it affect the scientific discussions of time until the nineteenth century. This lack was in part supplied by the suggestions of geology about development and also was pervasive of the whole setting of nineteenth-century thought. However, it did not attain to its full significance until the assertion of the biological theory of evolution.

Although there had been many suggestions of evolution from the time of the Greeks onward, some purely theoretical and some based on experiment, the antievolutionists were in the majority and in general determined the attitude of scientists until Darwin.[40] The general assumption of biology at the time was a mechanistic view in which the concepts employed were those of physics, including the Newtonian definition of time. Even those biologists who did not consider animals as machines did not question the validity for their science of the concepts which were proving so valuable in physics, but merely asserted that some additional concept was necessary in describing living organisms. The effect of the biological theory of evolution was to increase the importance of the concept of time; to make time a vital factor in reality. At the same time the tendency in physics was increasing to consider time a variable, which assumes values chosen so that the equations concerning position and movement of objects will be as simple as possible. It is difficult to relate these two ideas so that they can function in a single concept of time. This difficulty, however, did not appear at once since it was only gradually that the theory of evolution affected the fundamental concepts employed by biologists. In general, time continued to mean the same as had been stated in the Newtonian definition.

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[40] It is not within the scope of this essay to trace the development of the idea of evolution. The important point is that the significance it attained in the nineteenth century led to a modification of the meaning of time (cf. J. Royce on evolution and history in *The Spirit of Modern Philosophy*).

Lyell and Darwin, and most of the scientists who made the idea of evolution important in nineteenth-century scientific thought, were not interested in analysis of fundamental concepts; they were rather empirical scientists. Even "evolution" was a concept ready to hand since it had been developed by philosophy and become influential in many fields of thought; the successful application of it to various fields of nature tended to strengthen the dominant idea of a continuous change, and was naturally expressed in terms of a time conceived as the physicists and astronomers conceived it.

Even Spencer, whose interest was to furnish a general formula which should be applicable to all sorts of evolutionary phenomena, was not fundamentally interested in philosophical problems. He did, however, enter into a discussion of space and time in two different sections of the *First Principles*. In the chapter on "Ultimate Scientific Ideas" he pointed out that time is not ultimate, that is, not applicable to the noumenal world; but later he found that it had a relative reality. This is all that is needed for science. He thus opposed the idea of absolute time offered by Newton, and maintained that relative (or sensuous) time is what is meant by the term as it functions in any natural science. Beyond that we can, of course, have no knowledge. This is the general positivistic position and continues to function. It is not to be confused, however, with the effect of evolutionism on the concept. They are rather two distinct developments of the Spencerian philosophy. On the whole, the effect of the idea of evolution has been the more important.

Another effect of the development of biology on our thinking about time became explicit even more gradually, but may well be noted at this point: that is the idea of the "life-cycle" of a given organism. This is certainly related to the problem of time measurement, for it furnishes a unit of measurement which is not purely arbitrary. It might serve to differentiate more completely between the problems of time which arise in physics and in biology.

CHAPTER IV

THE RECENT PAST AND PRESENT

When the concept of time has been traced to the middle of the nineteenth century, most of the factors affecting its development have become apparent. To the influence of psychology, however, only slight attention has been paid, because of its relatively late development as an independent science. Most of this development would date after the midpoint of the century. With the beginnings of experimental psychology in Germany, the problem of the perception of time came in for due consideration. Herbart discussed carefully the nature of the perception of time and of space and the distinction between the two. He pointed out that for awareness of time it is necessary that both the beginning and the end of a series of elements be presented and grasped as together.[1] This indicates clearly the difference between the physicists' conception of time on the analogy of a line (made up of continuous, durationless instants) and the concept derived from experience which finds concrete duration an essential character of time.

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[1] *Psychologie als Wissenschaft*, § 115.

In line with this was the view held by Wundt. He attempted an analysis of time perception and concluded by showing that our experience of a sound and its repetition furnishes an illustration of the factors of time perception. There is in our consciousness, grasped together in a single experience, the first sound, the second sound, and a persistent image of the first. At the moment of awareness of the second sound, all the elements are present, either immediately or by reproduction, together with the awareness of a previous state in which only the awareness of the first sound was present to consciousness.[2]

Thus both Herbart and Wundt came very close to the notion that the perception of time is an atomic process. As has been pointed out, this essay is not concerned primarily with the perception of time, but the mention of Herbart and Wundt is made because the atomic nature of time perception might lead to a theory that time is atomic. In fact, James seems to have followed that line of reasoning. He discussed this subject very thoroughly and took up

[2] *Physiol. Psych.* (1st ed.), pp. 681–82.

several problems of time perception, such as the relation of memory to the perception of time. The most important in this connection is his discussion of the perception of empty time. What is so considered he showed not to be the perception of empty time at all but of our changing consciousness. The changes are caused by such things as changes in heart-beat, respiration, etc.

In the experience of watching empty time flow—"empty" to be taken hereafter in the relative sense just set forth—we tell it off in pulses. We say "now! now! now!" or we count "more! more! more!" as we feel it bud. This composition out of unities is called the law of time's *discrete flow.* The discreteness is, however, merely due to the fact that our successive acts of *recognition* or *apperception of what* it is are discrete. The sensation is as continuous as any sensation can be.[3] . . . . *The original paragon and prototype of all conceived times is the specious present, the short duration of which we are immediately and incessantly sensible.*[4] . . . . Let me sum up, now, by saying that we are constantly conscious of a certain duration—the specious present—varying in length from a few seconds to probably not more than a minute, and that this duration (with its content perceived as having one part earlier and the other part later) is the original intuition of time. Longer times are conceived by adding,

[3] W. James, *Principles of Psychology* (1899) I, 622. Reprinted by permission of Henry Holt & Co.

[4] *Ibid.*, II, 631.

> shorter ones by dividing portions of this vaguely bounded unit, and are habitually thought by us symbolically. Kant's notion of an *intuition* of objective time as an infinite necessary continuum has nothing to support it. The *cause* of the intuition which we really have cannot be the *duration* of our brain-processes or our mental changes. That duration is rather the *object* of the intuition which, being realized at every moment of such duration, must be due to a permanently present cause. This cause—probably the simultaneous presence of brain-processes of different phases—fluctuates; and hence a certain range of variation in the amount of the intuition, and in its subdivisibility, accrues.[5]

This view was extended by James so that it meant not merely that we perceive time as if it were discontinuous but that because of the way that we perceive it, and because of the difficulties of an infinite regress[6] involved if we consider time and change to be continuous, we must consider time itself to be discontinuous.

> "Infinitum in actu pertransire nequit," said scholasticism; and every continuous quantum to be gradually traversed is conceived as such an infinite. The quickest way to avoid the contradiction would seem to be to give up that conception, and to treat real processes of change

[5] *Ibid.*, I, 642.

[6] James's discussion of this, including his assumption that a continuous process must take place by infinitesimal steps, is open to question. However, it is historically significant as having led to an atomic view of time.

> no longer as being continuous, but as taking place by finite not infinitesimal steps, like the successive drops by which a cask of water is filled, when whole drops fall into it at once or nothing.[7]

It is clear from the foregoing quotations that James in no way confused the character of our perception with the character of that which we perceive. But he did indicate that the nature of our perception of time must affect our concept of that which we perceive. In his use of the term "real processes of change," which are conceived as taking place in discrete drops, he left room for a more abstract consideration of change such as is the province of physics. His argument at least suggests the "operational" view of concepts; that is, the concept is entirely expressed in a statement of the method of making certain measurements or observations. Thus very different concepts might be employed by the psychologists as a result of introspection and by the physicists as a result of measurement with complicated instruments. It might be pointed out, however, that confusion is almost bound to arise if the same word is habitually used for two such different concepts. This is particularly true since there are other very different views as to the meaning of our concepts.

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[7] *Some Problems of Philosophy* (1911) p. 172. Reprinted by permission of Longmans, Green & Co.

If one considers James's philosophy as a whole, it is clear that he found time to be a very real and vital factor in a developing world. He was one of the first of this period to give metaphysical importance to the idea of development and consequently to that of time. The same emphasis on the practical significance of time and the distinction between past and future in their relation to conduct was stated by C. S. Peirce. He pointed out that time certainly is real and that this involves a certain indeterminateness in the future. These statements of his gain significance in the light of the subsequent development of and emphasis on this point of view. I quote:

> The question to be considered is simply, What is the intellectual purport of the Past, Present, and Future? It can only be treated with the utmost brevity.
>
> That Time is a particular variety of objective Modality is too obvious for argumentation. The Past consists of the sum of *faits accomplis*, and this Accomplishment is the Existential Mode of Time. For the Past really acts upon us, and *that* it does, not at all in the way in which a Law or Principle influences us, but precisely as an Existent object acts. For instance, when a *Nova Stella*

bursts out in the heavens, it acts upon one's eyes just as a light struck in the dark by one's own hands would; and yet it is an event which happened before the Pyramids were built. The instance adduced (certainly a commonplace enough fact), proves conclusively that the mode of the Past is that of Actuality. Nothing of the sort is true of the Future, to compass the understanding of which it is indispensable that the reader should divest himself of his Necessitarianism—at best, but a scientific theory—and return to the Common-sense State of Nature. Do you never say to yourself, "I *can* do this or that as well tomorrow as today"? Your Necessitarianism is a theoretical pseudo-belief—a make-believe belief—that such a sentence does not express the real truth. That is only to stick to proclaiming the unreality of that Time, of which you are invited, be it reality or figment, to consider the meaning. You need not fear to compromise your darling theory by looking out at its windows. Be it true in theory or not, the unsophisticated conception is that everything in the Future is either *destined*, i.e., necessitated already, or is *undecided*, the contingent future of Aristotle. In other words, it is not Actual, since it does not act except through the idea of it, that is, as a law acts; but is either Necessary or Possible, which are of the same mode since (as remarked above) Negation being outside the category of modality cannot produce a variation in Modality. As for the Present instant, it is so inscrutable that I wonder whether no sceptic has ever attacked its reality.[8]

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[8] *Collected Papers*, V, 458 and VIII, 459. Reprinted by permission of Harvard University Press.

The strictly psychological problems as to whether time is perceived through a special sense (cf. Mach) or feeling—whether it is perceived in a single state or process, or a succession of states (Condillac, Mill, Herbart)—and the even more special problems which seem to have been the chief concern of the psychologists are not important for this essay. The suggestion of Münsterberg that time perception is based on various rhythmical physiological processes with respiration as the most important deserves note. This would seem to base time, or at least the various drops of time, on the nature and characteristic of the special organism.

In general, this conclusion can be drawn concerning the psychologists who have concerned themselves with this problem: When they have turned from the consideration of time perception to a consideration of time itself they have dealt with it in connection with real processes of nature and have been less concerned with time as a mathematical or physical abstraction or fiction. All, except Berkeley, seem to indicate that they assumed the reality of time, i.e., time is something other than its perception. The statement that time is the attribute of duration, which applies to real (i.e., physical and psychical) processes or objects, indicates that time involves two factors: some succession and some permanence. Its character as measurable is also involved. On the whole, the Newtonian conception of time is the background of their thought, even though time is treated less abstractly, and sometimes as a discrete rather than a continuous series.

There seems to have been little change in the psychological discussions of time with the opening of the new century. This is perhaps truer of the psychological work than of any other field. Much experimental work has of course been done in connection with the beginning and development of the perception of time, but it has been chiefly an extension of work already begun. Reference will be made only to certain investigations which seem to throw some light on the concept of time itself.

In writing of time Mary Sturt concludes that time is not real, nor a real characteristic of things, because our perceptions of it are too uncertain and varying. It seems wise to quote rather fully here in order to avoid misinterpretation of the position and argument.

> *No psychologist can accept time as something objectively real* and unchanging, since such a view reduces the experiencing mind to a mere observer, and the variations which are so noticeable a feature of the time-experience become just so many errors and failures in observation. Merely to catalogue the mind's lapses is a dispiriting task. The natural assumption is that time is a concept which is built up through individual and racial experience. It is then possible to trace the development of this concept and to note the different forms it takes under different conditions. Divergences from the normal are not errors, but rather curious adaptations to special circumstances. This involves the further assumption that time is subjective, i.e. that it is created by our own minds and is not something existing objectively like a table, nor is it a quality of objects such as a color.[9]

It is, or course, not certain that the fact that a theory makes a given task dispiriting is proof that the theory is false. Sturt's conception that time is a concept built up through individual and racial experience is in some respects similar to the operational view of the physicists. Her statements, however, raise several questions. First, just what does "unchanging" mean as applied to time? The most reasonable interpretation is uniformity, although that is not the idea naturally suggested by the phrase.

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[9] *The Psychology of Time* (1925), p. 2 (italics mine). Reprinted by permission of Harcourt, Brace & Co., publishers.

Second, is it intentional that there is no account taken of the idea "relative to the person" as in any way a factor which would account for the variations in estimations of time? This is surprising since this idea is so important in the writings of physicists, biologists, and even philosophers. One feels that Sturt's assumption seems to be that time is a totally uncertain affair, that it is subjective or created by our own minds, and that any comparison of durations is quite arbitrary. But while this is the starting-point, it is not the conclusion of the book. In fact, it is difficult to understand how these assumptions can lead to the conclusion without involving contradiction. The difference can be brought out best by a summary of the last chapter, using quotations as far as possible.

> To say that time is a concept is not to deny that it has a certain experiential basis. . . . Time as experienced possesses two main elements, and there are two others which are of less importance. Our experience is made up of a succession of mental states, and these states must be understood to include the whole complex of our awareness at any moment; our thought, our bodily sensations, and the appearance of the external world. As experienced, a moment of time is simply one of these states. We label these states in reference to a conventional time scheme, e.g. 5 o'clock on last Monday afternoon, but the

meaning to which this phrase refers, is the experience which occurred at that moment. . . . . In consequence of this, the shortest span of time that can be directly apprehended is the shortest time in which we can experience a mental content. [It should be noted that there is some ambiguity in this statement. There seems to be reference to a *real* time as opposed to time which can be experienced. This is hardly consistent with the earlier sections quoted.] This is far from being the smallest one imagined or even measured. Hence arise the difficulties over the divisibility of time.

The second main element in the time experience is that such states of consciousness do not come to us disconnected, but as filling a place in a time scheme. Each experience of our own is apprehended as adding a new bit to our past. . . . . This consciousness of the "time-setting" of each event is part of our experience, it is not something we add to an unfixed event.[10]

From their individual time scheme, most people pass to a universal one and, in so passing, they leave experience behind. Time, as we apprehend it, does include a reference to our own past history; it does not include a reference to a world scheme. . . . . It follows from this assumption of a world time scheme, that events are not fixed for us only, but also for the world and for other people; and we arrive at once at Universal Time. Now this time cannot be the time experience of individuals, it must be invariable; and thus we get Newtonian Time, measured by some imaginedly perfect time-piece ticking with the heart-beats of the universe.[11]

[10] *Ibid.*, pp. 141–42.

[11] *Ibid.*, pp. 143–44.

It is not clear in the text how one passes from a variable individual time to an invariable universal time without assuming that there is a universal time which is independent of the experience. In fact, the "imagined clock which ticks with the heart-beats of the universe" seems to be the inevitable setting-up of an objective criterion for time. The psychological basis which Sturt goes on to suggest does not appear to be a psychological basis, but rather evidence of a time process which is independent of our minds, i.e., strictly non-psychological.

All the same this Universal Time has a certain psychological foundation. It is an observed fact that we can cooperate with other individuals in a way that depends on common time, and we do observe apparently regular changes, or at least *changes* in the things about us.

There is no intrinsic reason, however, why time should not be strictly reversible, and unroll backwards as it does in the dream already quoted. . . . . The reason it does not do this more often is probably that we have formed a prejudice in favor of the cause preceding what we regard as its effect. [This argument depends on a definition of cause, independent of mere time order. Sturt does not include such a definition.] It is our accumulated knowledge of external events which keeps time in its usual order.[12]

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[12] *Ibid.*, pp. 144–45.

This is not the same view as that connected with the theory of relativity.

> On the view put forward, a moment of time is not something which, though it may be different with different people, yet has consequences which may be discernible to others, it is simply a state of mind peculiar, as all states of mind are, to the experiencer.[13]
>
> Time is then part of our adaptation to our environment; and yet most men crave to be free of it, at least to some extent.[14]

This can be attained either completely, in which case there is a chance of one's being thought mad, or partially, as in daydreams, contemplation, etc. One still wonders if this is a completely subjective view of time. Just what is our environment? Does it involve progress? Or is there any progress in our adaptation to it? If so (and it would seem that "yes" is the answer to the two latter questions), time must be real and objective in some sense; unless it be, of course, that our environment is also completely subjective. This, however, does not seem to be the view expounded.

This discussion is interesting for at least two other reasons. It reflects the great difficulty which attends the thoroughly positivistic position—a difficulty for physicists and biologists as well as psychologists. It also suggests the importance of such biological concepts as environment and adaptation in determining our contemporary thought about time.

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[13] *Ibid.*, p. 146.

[14] *Ibid.*, p. 149.

Another recent treatment of this question, and one also reflecting the influence of biology, is that expressed by Ivy Mackenzie in an article called "The Biological Basis of the Sense of Time." He maintains that neither space nor time are simple but are "the outcome of processes of mental abstraction representing the highest activities of the human faculty." They have "their origin in the processes of which counting is an abstraction," that is, "in the recognition of objects which were similar and simultaneous, on the one hand, and which, on the other hand, could be combined or abstracted into a single whole by successive enumerations. Such simple processes, in all probability, constitute the basis of measurement on which the orderly regulation of experience and scientific abstraction depend."[15] But counting is a late development and presupposes "doing" space and time. "Such doing of space and time is to be regarded as the condition of a special kind of movement, movement that may be characterized as organismal locomotion, and distinguished from movements in plants, movements associated with inorganic terrestrial changes, or movements in celestial mechanics."[16] It depends on the fact that an organism is essentially "a becoming." "Now all movement may be traced ultimately to the rhythmic contractions of the primitive unicellular organism, the 'refractory period' which regulates the rhythmic change is the first doing of time." But "the doing of time is only partly reflected in locomotion."[17] Stimuli may be conserved for the future. Thus, the organism escapes the present in the past or the future. The evolutionary process shows more and more complete grasping of the past and future in the present. "No animal is to be compared with man in the extent to which, through organic time, the experience of the past is represented in the present."[18] The ability to count is a critical step in attaining fully to the experience of time.

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[15] *Aristotelian Society*, Suppl. Vol. V, 65.

This also is a biological treatment of time, but, unlike the earlier one, is thought to be quite in accord with the theory of relativity.

[16] *Ibid.*, p. 67. [17] *Ibid.*, p. 71. [18] *Ibid.*, p. 74.

This is because "there is no distance in space and no interval of time which is invariable and independent of the system of relative movements to which the observer is attached."[19] This correlating of a biological and psychological theory with the result of the theory of relativity is rather unusual; but it is not that which is most significant, but rather the close association of time perception with the normal psychological conditions of human life. After citing several cases of loss of memory, and with it rather complete changes in mental and physical characteristics, Mackenzie concludes that "the restoration of memory or continuity of experience or feeling of time is imperative to a complete restitution, or recovery of will-power, of interest, of attention, and of normal emotional experience."[20] This is part of the theory of the origin of personality, which is connected with the development of the ability to count, to talk, and to manipulate and as a result of these to analyze experience into self and surroundings. In this way certain activities which had been organic or automatic (as memory, emotion, impulse) attained to their complete conscious form and came under the control of reason. "Time is, then, the generic term for a series of relations which constitute the binding element in the creation we know as personality."[21]

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[19] *Ibid.*, p. 82.

[20] *Ibid.*, p. 101.

This theory is similar to Sturt's in that it makes time a product of the organism, but it is not a subjective affair at all; rather it is the result of the nature of those concrete processes, which are displayed both in evolution and within every organism. (It might be suggested that this view could be extended by making these processes displayed also in all vibrating systems.) The connection between time and counting, and also between time and personality, reminds one of Plotinus. This similarity is not obvious because of the great differences in expression, but if one can rid Plotinus' thought of its mysticism and of a sort of aesthetic vagueness, the similarity becomes apparent. Compare, "and we [i.e., human souls] stirring to a ceaseless succession, to a next, to a discrimination of identity and the establishment of ever new difference," with the idea of counting and its effect in producing both the experience of time and personality. This view also furnishes a reason for the general uniformity which we find in time systems of different individuals of the same species in spite of rather great variations in estimations of periods of time.

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[21] *Ibid.*, p. 102.

Another very important philosopher of the late nineteenth century and one who discussed time in considerable detail was Lötze. He was closely connected with the psychological treatment of time which has already been discussed, but was opposed to it both because he did not accept the Newtonian idea of empty time and because he avoided the subjectivity of some of the psychological views. This also involved opposition to the Kantian view of time as a pure form of perception. In his *Metaphysics*, particularly Book II, chapter iii, he showed in detail the various contradictions to which either of these views lead. His positive view is not quite as clear as his rejection of other views, but he connected time more definitely with concrete becoming. In his criticism of the current views of reality as timeless, he pointed out that the real difficulty lies not in the idea of a timeless external world but in conceiving of timeless mental life. Since for Lötze this constituted ultimate reality, it is clear that he held that time is a real factor in the world. He did not give in detail a definition of time, and his importance in connection with this problem lay in showing the difficulties in the current views. In a very real sense, however, his view is suggestive of many of the views of the twentieth century.[22]

But with the exception of a few writers who maintained a theory of real and objective time, and attempted to derive this concept from concrete events, most writers were accepting the Newtonian view of time, as far as physical events were concerned, but adopting the Kantian critical position or the Hegelian interpretation of this which led to the idea of an ultimately timeless reality or absolute. Writers who were particularly concerned with the problem of the reality of time will be discussed in the next chapter; two others, Royce and and Bosanquet, are chosen as representing two different but characteristic attitudes of this period.

Royce took fully into consideration the idea of evolution but found it inapplicable to ultimate reality. However, his view was much more definitely concerned with the course of concrete events than had been the earlier philosophers of this tradition, particularly the Germans. He treated space and time in a similar fashion. For him they are two interconnected but distinct wholes. The general method of approaching the problem is the one that was noted in the Platonic tradition. This is to treat time and eternity as opposite concepts which can be defined best together. The stress has been either on time or on eternity, according as one was interested chiefly in natural science or in logic and the nature of thought. This, then, was Royce's general method, and in his case the emphasis was on the eternal. But in no way was time swallowed up in eternity. The temporal world is what we know, but taken in its wholeness it is an eternal world. As far as Royce offered a philosophy of nature, the temporal order set the problem. But he was always sure to remind us that a philosophy of nature, even nature interpreted as including finite minds, is only a part. Our experience of time as a specious present shows us what eternity is, and the eternal is the more ultimate concept.

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[22] Cf. Bergson, Carr, and Whitehead.

Closely connected with his treatment of time is the question of an evolutionary theory of being. In *The World and the Individual*, Royce did full justice to evolution as a significant concept for our interpretation of nature. But in *The Spirit of Modern Philosophy*, he undertook a criticism of that philosophy which considers evolutionary theories as a basis for metaphysics. The care of this refutation indicates the growing prevalence of the view which he opposed. I quote the general criticism:

> On the other hand, what is more obvious than that *if* one conceives man as the product of the physical evolution of the types that we have heretofore been discussing, if one says that a planet-crust, at a particular stage of its history, brought forth man, while the heat of a slowly dying sun sustained his life, as it had done the lives of his countless animal ancestors before him,—if one holds all this to be true, then one must indeed look with equal wonder upon the power of such a creature to conceive at all of the real universe, or of the eternal, and upon the naïveté that trusts, without analysis and criticism, his notions of space and time, his natural perceptions of the outer world, as if they were sure to be well-founded. The marvel of marvels, that this being, evolved from inorganic nature, from the stuff and the energy of a cooling solar system,—this mortal bit of mechanism—should after all know, should look forwards and backwards to eternity, and learn so much of the nature that gave him birth,—such a marvel surely calls for a deeper scrutiny. The world where such things appear is surely not what it seems; and the lesson is that, in the critical study of

just this knowing power of ours, in the scrutiny of our most fundamental ideas, is to be found, if anywhere, the key to these mysteries.[23]

Irrespective of Royce's own conclusions, his argument indicates very clearly the difference between the evolutionary view of any of the natural sciences and an evolutionary philosophy. It also indicates the dangers of drawing conclusions from our perceptions of time as to its nature except on the basis of a full understanding of all assumptions involved. As far, then, as ultimate metaphysics is concerned, Royce's treatment of time is negative. But he did not dismiss it by pointing out that it is not ultimate, but goes on to indicate what significance it actually has. In this positive treatment Royce connected time with the idea of will. In fact, he found that it had no meaning apart from the will. "Time is in essence the form of the finite will."[24] The absolute may escape this temporal quality, but it characterizes all change and attains its full significance in connection with volition. Royce's Absolute, like all proper absolutes, is not a process, although processes may be included, but only as in some way transcended. The emphasis is on the transcendence rather than on the process: The absolute is the complete eternal.

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[23] J. Royce, *The Spirit of Modern Philosophy* (1892), p. 338. Reprinted by permission of, and by arrangement with, Houghton Mifflin Co.

[24] From *William James and Other Essays* (1911), p. 271. By permission of the Macmillan Co., publishers.

The connection between time and the will has not merely philosophical tradition back of it (cf. Schopenhauer) but would appear to be in line with many of the psychological discussions (cf. Sturt and Mackenzie). In spite of the eternal character of the absolute, Royce seems to have found nature, and therefore time, interesting and deserving real philosophical consideration. It would be interesting to know how far he would have accepted the "operational" view of this concept, or rather "concepts," since the time of the physicist if considered in a merely "operational" meaning can never be identical with that of the biologist, or psychologist; in fact, probably it varies within a single science, depending on the operations involved in different work.

Bosanquet dealt rather more cavalierly with time than did Royce, and is perhaps more characteristic of the idealistic tradition for that reason. His general method of interpreting experience was in terms of our higher moments rather than in terms of the obvious in experience. It is characteristic of these higher moments that differences are included but transcended. Among the five types of such differences which Bosanquet discussed are those due to time, which are transcended more or less completely in our higher experiences. These differences are thought of as completely transcended in the Absolute—or, in other words, are ultimately illusion. Activity which is completely self-conscious is timeless.[25] This timelessness is its *durée*. Time involves both succession and continuity, which are also aspects of the finite self. But timelessness is itself a constituent of time, thus transcending mere successive continuity. This may be an absolutistic way of pointing to the same character which in other settings is the atomicity of time; that is, in pointing to the fact that the moment of time involves completion as well as incompletion. If it is not, it does not seem an intelligible view.

McTaggart's treatment of the problem of time in as far as he demonstrates its unreality will be discussed in the next chapter. This he did in a rather unusually interesting and thorough way. But, in addition, there is an interesting feature in his analysis of the concept of time. His theory is that time is an inadequate way of regarding eternal reality. This is usual enough. He next raised the question as to what determines the order of events on any such theory. The conclusion is that the order is determined not by the nature of time and its relation to events but by the degree of adequacy with which any event represents reality. Thus he supposed that the time series is a series arranged in the order of adequacy and timeless reality is the last stage in the series. We naturally conceive of this as future, but it is really not future. There is no a priori reason why we might not consider this series as reversed or with the least adequate stage in the middle of the series. But McTaggart found evidence in Christianity, in the practical aspect of the future, for considering that eternity is at the end of the future.[26]

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[25] B. Bosanquet, *The Principle of Individuality and Value*, esp. p. 338.

There are several interesting aspects to this view. First, it is another attempt to put on a well-founded basis the apparent irreversible character of time. This is done on practical rather than on purely rational grounds. Second, it is an attempt to make more definite the idea of an ultimately eternal reality in which, however, time has some significance. Third, the idea of the practical importance of the order of the time series gives time a significance perhaps greater than one would expect from the rest of McTaggart's discussion. This practical importance is certainly part of the problem of the relation between time and value and will be discussed in the final chapter.

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[26] J. M. E. McTaggart, "The Unreality of Time," *Mind*, Vol. XVII (N.S., 1908).

While the view of most biologists on the subject of time seems to follow closely the Newtonian view,[27] J. S. Haldane's position is determined in part by his interest in the Hegelian development in philosophy. In his Gifford lectures[28] he expressly states that he sides with Kant in considering space and time as forms of mind and sees no reason for modifying the Kantian view because of any of the developments of physics. His view is not a strictly critical one, however, because of the Hegelian tendency, and he also points out that space and time are orders each of which is part of the expression of a spiritual whole or absolute. Thus his view is much like that of the philosophers who have just been discussed. But because of his biological interest there are interesting special points in his view. First, he asserts that scientific results are incomplete abstractions from reality, and that their abstract character must be remembered if they are to be valuable. Second, because of his investigation of the phenomena of breathing under different conditions, he reaches the conclusion that the distinction between an organism and its environment is a rather arbitrary matter; this is in line also with his monistic view, but is a conclusion which he reached quite independently on biological grounds. If this view is held, it undoubtedly affects our interpretation of the relatedness of the factors in both biological events and other events. That is, the conclusion of biologists and physicists on the subject of time cannot be as independent as we might otherwise hold since the subject matter of the biologists (i.e., organisms) cannot be set off in sharp contrast from the inorganic environment which is the field of physics. Third, since the work of the sciences is necessarily abstract, it is possible to point out this unity of organism and environment and yet to maintain that the concepts of physics are not adequate to the biological sciences, or those of biology to psychology.

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[27] Cf. Henderson, *The Fitness of the Environment;* S. Eldridge, *The Organization of Life.*

[28] *The Sciences and Philosophy.*

Fourth, particularly in the process of adaptation, there is a cumulation which involves a characteristic of time not included or even considered by the physicist. This cumulative character of time is generally recognized by biologists and is important also in much of the philosophy at present. Fifth, the most important contrast between physical and biological sciences is in the contrast between *chance* in inorganic nature and *order* in the living world. Sixth, because of his evolutionary view of the world, it is necessary to maintain that the order of the living world is at least immanent in the inorganic. This order manifests itself in the progressive adaptation of an organism to its environment, and thus is clearly a temporal affair. It would appear, then, that whatever characters of order appear in such events (as adaptation) are immanent in all processes, and therefore might be said to be characteristic of time, provided we are using that term in an inclusive sense. This conclusion is not stated by Haldane, but is implied in his philosophical and biological position.[29]

The problem as to the relationship between the concepts of physics, those of biology, and those of psychology is of course a very real one, and one on which there seems to be little agreement. As has been indicated, Haldane maintains that they are inevitably different because the two sciences are abstractions made for different purposes or from different points of view. At the same time they are related since there is but one reality from which abstractions are made. Since this reality is spiritual, it would appear that the concepts of psychology (at least of a valid psychology) would legitimately be of greater value than others.

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[29] For his statements see *Organism and Environment*, *passim*, but especially the last chapter.

There is also the philosophy of biology which is related to Bergson's general position and which follows the vitalistic biology of Driesch. This would involve not merely noting the contrasts between physical and biological concepts but maintaining that the former are of essentially no philosophical significance but merely of perhaps practical value. In this connection I quote from J. Johnstone, *The Philosophy of Biology*. He points to the contrast between the idea of duration and that of empty time, which is the concern of the mathematician and the physicist.

> The more we reflect on it the more we see that mathematical time is only a way of seeing things apart from each other. Things become extended in time as they become extended in space. Whether occurrences capable of analysis by methods of physics are what we call past or future occurrences they are all given, in that each of them is only a phase of the others. Duration belongs to the organism. The past is known because all that has occurred to the organism still persists in its organization. The future is unknown because it has still to be made. Duration is therefore a vector—something having duration and the organism progresses out of the past into the future. It grows older but not younger.[30]

A more mechanistic view is that of H. S. Jennings, but equally definite in indicating the importance of the passage of time, and its cumulative character:

> The universe is a system that in time comes to life: . . . . becomes conscious. . . . . This production of life and its attributes is one of the revelations of the essential nature of things; something never to be forgotten in considering the properties of the elements of which the world is put together. . . . . It is, as one would expect, an evolutionary philosophy.

The universe was not originally given complete, its development cannot be predicted from its beginning to its end. "With the passage of time, it brings forth new things; things that are ultimate in their nature, things that can be known only by experiencing them."[31] In spite of his mechanistic biology, he seems to cite Lloyd Morgan and Bergson with approval.

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[30] P. 337. By permission of The Cambridge University Press, publishers (New York: Macmillan Co.).

An interesting attempt to relate physics and biology is made by F. H. Pike in *The Driving Force in Organic Evolution*. The starting-point of this essay is the recognition of a certain type of opposition between the physical concept of entropy and the biological concept of evolution. (The same sort of opposition would exist with any idea of evolution.) This opposition disappears if the sun is recognized as an unfailing source of energy which has a cumulative effect on living organisms and is a factor in the production of new forms and structures. This view would be consistent with the idea of entropy only because it deals with a limited sort of evolutionary process. It would permit us to make the physical concepts, including the physical concept of time, ultimate. But it should be pointed out that any general theory of evolution could not have this escape from the difficulty. One further thing should be noted. The introduction of the idea of entropy might suggest that the concept of empty time of Newton is not adequate even to the physics which antedates Einstein, for the second law of thermodynamics, no less than a theory of evolution, assumes that the passage of time makes a real difference and time can no longer be considered the empty affair with which Newton was concerned. That this law refers to a sort of antievolutionary process, or degradation, is significant only as to the relation between time and value, not as to the reality of time.

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[31] *The Universe and Life* (1933), p. 93. Reprinted by permission of Yale University Press.

The conclusions based on the writings of biologists are inevitably somewhat sketchy because the present interest of most biologists seems to be in special problems rather than in general concepts. It is probable that the near future will see a change in this respect started by the attempt at an analysis of fundamentals which is so general in the physical sciences at present.

As was indicated in the first chapter, the most important recent changes in the concept of time are those which are connected with the development of physics. The two theories which have been most influential are the theory of relativity and the quantum theory. The problems involved and the general tendencies have already been indicated. There remain wide variations in opinion as to their philosophical significance.

Among German writers there seems to be a definite tendency to find in the theory of relativity a confirmation of a certain type of Kantian philosophy. One of the most important of these is Cassirer. He states that the absolute space and time of Newton should be considered as mathematical ideals and not as involving the problem of existence any more than does pure number. This was certainly not Newton's view, but is much the traditional Kantian interpretation of Newtonian physics. Cassirer extends this interpretation to take into account the theory of relativity, pointing out the epistemological significance of the latter:

> The Copernican view could point, when it appeared, to no single new "fact" by which it was absolutely demanded to the exclusion of earlier astronomical explanations, but its value and real cogency lay in the fundamental and systematic clarity, which it spread over the whole of the knowledge of nature. In the same way, the theory of relativity, taking its start in a criticism of the concept of time, extends to the field of epistemological problems, not merely its application and consequences, but from its very beginning.[32]

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[32] E. Cassirer, *Substance, Function, and the Theory of Relativity* (1923), p. 355. Reprinted by permission of the Open Court Publishing Co.

This might be taken to mean that the general epistemological assumptions upon which the change from Ptolemaic to Copernican astronomy had been made are extended in their application and clearly demonstrated in the change from Newtonian physics to relativity. The nature of these epistemological assumptions Cassirer indicates in the succeeding discussion.

He continues with a detailed discussion of the question of time. He begins by reminding us that Kant had treated space and time on the basis of Newton's definitions but had transformed the meaning of these definitions by his critical interpretation of space and time as forms. Cassirer then raises the question as to whether the theory of relativity leads us as far beyond the Kantian treatment of time as it does beyond the Newtonian, and comes to a negative conclusion. Further, he states very clearly that the concept of time as influenced by the theory of relativity is inextricably bound up with a theory of measurement.

> Everywhere physical thought must determine for itself its own standards of measurement before it proceeds to observation. There must be established a certain standpoint for comparison and correlation of magnitudes; certain constants must be established at least hypothetically

> and in a preliminary fashion before concrete measurements can take place. In this sense each measurement contains a purely ideal element; it is not so much with the sensuous instruments of measurement that we measure natural processes as with our own thoughts.[33]

We see here at once that there is a separation of the sensuous from the intellectual. One is inclined at first to find in this an approach to positivism, but Cassirer quite expressly denies this. The factor assigned to the work of the intellect is not to be considered arbitrary. Nor is it to be thought that the theory of relativity has any significant relationship to positivism.

> The infinite multiplicity of possible systems is not identical with the infinite indeterminateness of the values to be gained in them—in so far as all these systems are to be related and connected with each other by a common rule. In this respect, the principle of relativity of physics has scarcely more in common with "relativistic-positivism," to which it has been compared, than the name. When there is seen in the former a renewal of ancient sophistical doctrines, a confirmation of the Protagorean doctrine that man is the "measure of all things," its essential achievement is mistaken. The physical theory of relativity teaches not that what appears to each person is true to him, but on the contrary, it warns against taking appearances, which hold only from a particular system, as the truth in the sense of science, i.e., as an expres-

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[33] *Ibid.*, pp. 364–65.

> sion of an inclusive and final law of experience. The latter is gained neither by the observations and measurements of a particular system nor by those of however many such systems, but only by the reciprocal coördination of the results of all possible systems. The general theory of relativity purports to show how we can gain assertions concerning all of these, how we can rise above the fragmentariness of the individual views to a total view of natural processes. It abandons the attempt to characterize the "object" of physics by any sort of pictorial properties, such as can be revealed in presentation, and characterizes it exclusively by the unity of the laws of nature.[34]

Two things are clear from the foregoing quotation. The theory of relativity, in passing from science to epistemology, is transformed into a theory of the absolute. This position that epistemology and metaphysics necessarily involve an absolute is a view held by many others as well as this group of Kantians (cf. below, Northrup). Further, the quotation indicates a preference, also very widespread, for intellectual rather than sensuous, mediate rather than immediate knowledge.

In accordance with this distinction between sensuous and intellectual knowledge, there is the distinction between psychological and physical time.

[34] *Ibid.*, pp. 392–93.

> But the question as to which of the two forms of space and time, the psychological or the physical, the space and time of immediate experience or of mediate conception and knowledge, expresses the *true* reality has lost fundamentally for us all definite meaning. . . . We can cancel neither of them in favor of the other and exclude it from the complex, but we can refer each to its definite *place* in the whole.[35]

Here there is still a theory of an absolute; but while intellectual knowledge is preferred to sensuous, it alone is not adequate to philosophy, although it is to science. After a short passage, which is omitted here, the paragraph continues: "The two standpoints can be understood in their meaning and necessity; neither suffices to include the actual whole of being in the idealistic sense of 'being for us.' "[36]

The concepts of space and time play their part in other fields than that of science, and all such meaning must be taken into account in any final concept. The fields of history, painting, and music are specifically mentioned. All these manifestations are thought of by Cassirer as related, as following some underlying law, and this law could be determined by noting the common characteristics of all the varying concepts of time. But for the complete concept, not merely this underlying general form, but also some systematic account of all the variations, must be included.

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[35] *Ibid.*, p. 454.

[36] *Ibid.*, p. 450.

As is evident, Cassirer's interest is essentially epistemological, the theory of relativity is primarily an illustration of his views which were independently determined. But similar views are expressed by those who are fundamentally interested in the physical theory. In *The Reign of Relativity*, R. B. H. Haldane refers to both Riemann and Schlick and points out the way in which their views differ from that of Cassirer, as well as certain similarities. All three make the problem of measurement a central one and definitely bound up with relativity.

Haldane gives the following quotation from Riemann:

> The question of the validity of the hypotheses of geometry in the infinitely small is bound up with the question of the ground of the metric relations of space. In this question, which we may still regard as belonging to the doctrine of space, is found the application of the remark made above: that in a discrete manifold the principle or character of its metric relations is already given in the notion of the manifold whereas in a continuous manifold this ground has to be found elsewhere, i.e. has to come from outside. Either, therefore, the

> reality which underlies space must form a discrete manifold or we must seek the ground of its metric relations (measure conditions) outside it in binding forces which act on it.[37]

This is an interesting analysis of the problem of measurement and applies to time, particularly to the time of space-time, quite as well as to space. Cassirer would consider the chief condition of measurement to be due to the work of the mind; Riemann, on the other hand, finds it in physical binding forces. It should be noted that Haldane, in referring to this, points out that Freundlich and Schlick find a similar need for binding forces to make measurement possible and suppose them to be in "relations between the intervals of points in motion and the influence of a gravitational field."

Schlick runs a theory which is very similar to Cassirer's in distinguishing between objective physical time and subjective psychological time. The latter is

> an everchanging intuitional factor, which makes one and the same objective event appear, according to mood and attentiveness, now short, now long; a factor that vanishes altogether during sleep, and bears an entirely different stamp according to the wealth of associations

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[37] *The Reign of Relativity* (1921), p. 106; quoted from Riemann. Reprinted by permission of Yale University Press.

> of the experience. In short, it is easily distinguished from physical time, which only signifies an arrangement having the properties of a one-dimensional continuum. This objective order or arrangement has just as little to do with the intuitional experience of duration as the three-dimensional order of objective space has to do with the intuitional experiences of extension as presented optically or tactually.
>
> Just because the latter (i.e., the physical time) is purely conceptual it is quite impossible—contrary to the opinion of many a follower of Kant—for intuition to give us the slightest information as to whether physical space is Euclidean or not.[38]

No intuitional evidence may properly be given as a basis for a distinction between physical space and time.

The intuitional psychological spaces and times are first given and physical space and time are later constructed in accordance with the necessities of everyday life on the basis of perceived functional relations between tactual and visual spaces and between various time experiences. A point in space is fixed by pointing to it, this pointing being a bringing about of space-time coincidence of elements that are usually separate. While, however, physical theory starts from certain psychological data, it goes far beyond it in one respect. The psychogenetic analysis of the idea of objective space ends in the conception of the space-time coincidence of two elements of perception; while physics introduces as its ultimate indefinable conception the coincidence of two objective events. As Schlick points out, those two types of coincidence would be the same on a strict positivistic theory (cf. Mach, for example). The statements of physics are "shorthand" expressions for perceptual reality. But Schlick points out other possible interpretations. We may accept the physical elements as real since they are measurable, i.e., since measurability is considered by physics to be an adequate criterion of reality, the same criterion may legitimately be adopted by epistemology. Schlick gives three reasons for preferring this view. Positivism is arbitrary; it lacks continuity; whereas this latter view justifies our preference for the simplest theory since it contains the fewest arbitrary concepts.

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[38] M. Schlick, *Space and Time in Contemporary Physics* (1930), p. 79. Reprinted by permission of Oxford University Press, publishers.

It is interesting to note the tendency to give two definitions of time: the one dealing particularly with measurement and other problems of physics, the other referring to elements in immediate perceptual experience. The opposition between these two ideas is certainly made more apparent than in the earlier periods because of the greater exactness of the physical concept and because of the new treatments of the problems of measurement. It seems like the appearance of two fairly distinct concepts, which had formerly been treated together because of lack of exactness, but whose difference was really implied in many of the earlier discussions. In both the psychological and the physical concepts there is recognition of an important subjective factor by the German writers just discussed.

Among many English writers there is a similar subjective line; for example, Haldane and Eddington. Eddington's work is chiefly from the scientific point of view while Haldane's is more similar to the views which show Hegelian influence, but with special consideration of scientific problems. Because it introduces a different approach, Eddington's will be treated in some detail. He starts with the meaning of simultaneity and from that approaches the differentiation of psychological and physical time. (This is not unlike Schlick.) Our usual way of thinking of events is as stratified into nows which extend throughout the universe.

These world-wide nows are created by ourselves and dependent on our geocentric outlook. But it is difficult for us to recognize this subjective and artificial character because we are so in the habit of extending the now of which we are immediately conscious here, inside us, to the whole universe. The here-now is immediately given; the extension of it is the work of the mind. The extension involves several steps: first, extension to the events which we perceive through the senses to be taking place around us; then, the consideration that the distance of an event from the perceiver results in a corresponding passage of time between the event and the perception, and in terms of this passage of time, the extension to the whole conceived universe. This subjectivity is fully taken into account in the theory of relativity.

> The relativity theory recognizes these *world-wide events* for what they are—artificial partitions, constructed for purposes of calculation. I may add that it in no way tampers with the *local instants* which form the stream of consciousness. . . . It leaves entirely untouched that time-succession of which we have intuitive knowledge and confines itself to overhauling the artificial time scheme which Römer first introduced.[39]

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[39] A. S. Eddington, *The Theory of Relativity and Its Influence on Scientific Thought* (1922), p. 18. Reprinted by permission of the Clarendon Press, publishers.

In his most recent book Eddington carries the distinction between the reality of immediate experience and the artificial character of scientific concepts even farther and gives a subjective definition of existence. "For my own part, any notion that I have of existing is derived from my own existence."[40] The external world described in physics may also really exist, but the interest of the physicist is confined to descriptions of relations in it; thus Eddington's view is not completely positivistic, but is some form of idealism. "Time," as the term is used by physicists, is just a term describing relations, and predominantly measurable relations. Anything else which may be inferred from the relations of selves would be another concept, although it may be one which is as frequently called "time" as is the physical concept. For example, consciousness ordinarily reveals the irreversibility of certain relations, and this is attributed to the time process. This is part of the immediately perceived distinction between past, present, and future, which indicates a certain open character to the time dimension at the future end. For physics a signpost indicating the irreversible nature of time has also been found in the concept of entropy. This involves the idea that the universe will end, and also that it had a beginning. This is a purely physical signpost and reducible to mathematical terms. Another signpost, which is not entirely subjective, but which is not reducible to mathematical terms, consists in the dynamical nature of time, which underlies the evolutionary process, and which ultimately connects time with value. Finally, the idea of an expanding universe—an idea developed in connection with the theory of relativity—gives a definite direction to time. These discussions indicate that Eddington does not separate the physical and the psychological concepts of time as fully as at first appears, since it is possible to point to so many corresponding characters.

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[40] From A. S. Eddington, *New Pathways in Science* (1935), p. 25. By permission of the Cambridge University Press, publishers (New York: Macmillan Co.).

He is also concerned with the philosophical influence of the quantum theory and concludes that it points in the direction of indeterminism; that all future events are to some extent indeterminable owing to the fact that protons are never quite definitely in any place, but only have the probability of being there. This evidence from the quantum theory gains weight because it is not an exception to a rule, but the general rule itself.[41] This places the burden of proof definitely on the determinist. He concludes the article by saying that various developments of science, relativity, quantum, wave mechanics, all indicate the inadequate view which finds the physical world a mechanism as opposed to the direct revelations of human experience and introspection into human purposive action. He makes no particular application from this conclusion to the concept of time, but it is clear that this reasoning is in the direction of a more complex concept than that formerly involved in the natural sciences, one including both continuous and atomic characters, and that, if an indeterministic view is reached, time inevitably becomes a more significant concept than on the older deterministic and mechanistic scheme of physics. The passage of time thus effects a real difference in the nature of things. It seems further that this discussion of determinism tends toward a single complex concept rather than in the direction of the ultimate separation of the physical and psychological concepts of time.

In a somewhat similar fashion Weyl[42] argues

[41] A. S Eddington, *The Decline of Determinism*, p. 149.

[42] *Mind and Nature*, chap. i.

for the essential subjectivity of our sense perceptions and therefore of such concepts as space and time which are based on them. He notes that there is a definite contrast between the space and time of sense perception and the four-dimensional continuum (space-time) which physics employs in describing the external world. The objective world of science is definitely determined by the contributions of the intellect. Thus physical theories can be stated adequately only in symbols and cannot be represented by models. However, this constructed world is related to the world of perception, and this relation can be defined in terms of the operations employed in making measurements and other observations. Like most recent writers, Weyl finds the meaning of simultaneity a central problem in connection with time. Simultaneity, as well as past and future, can be defined only for a given observer and in terms of the velocity of light. This discussion leads to three conclusions which have some bearing on the problem of time: First, that measurements of time and space are dependent on the assumption that light signals can be sent from every point in space and observable at all points. Second, this world of measurements is objective because it is based on a common assumption but is always relative. Immediate experience reveals absolutes, but such absolutes are necessarily subjective. Third, the objective world merely exists; it does not happen. A section of it comes to life before the eye of consciousness. This last conclusion is particularly significant because it relegates any passage of time to the subjective world, the objective world being merely an assumed set of relations and therefore static. This is, of course, a common-enough implication, but is stated by Weyl with unusual definiteness and clarity. It is not clear, however, just what the implications of coming to life before the eye of consciousness are unless some sort of passage applies, perhaps to a real world which is neither the objective world nor the subjective world. But there is no indication that such is Weyl's meaning.

The same sort of conclusion about the distinctness of the objective and the subjective is drawn from the evidence of the quantum theory. That theory not only negates strict causality but it makes the opposition between subject and object more important than in classical physics.[43] The particular point here is that if it further separates the objective and the subjective, it must make even more clear than before the essential difference between the objective and measurable time of the physicist and the subjective time of immediate experience. It is also worth noting that Weyl finds the indeterminacy of the quantum theory to be an essential of the objective world. The theory is such that we may not consider our measurements as incomplete statements of exact laws; we must admit an essential indetermination. He does not point out the conclusions concerning time which naturally follow the admission of indetermination, but it is clear from earlier discussions and also from those of contemporaries that time necessarily becomes a more important metaphysical concept on any such view.

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[43] *Ibid.*, p. 82.

Niels Bohr is equally definite in noting the subjective character, only in his case it pertains to all experience, even the measurable experience of the physicist. He also concludes that the quantum theory involves a departure from strict determinism. His view of space and time appear to be more Kantian than those just discussed. They are forms of measurement dependent on limits of accuracy which will guarantee universality within those limits. This would seem to indicate that neither the theory of relativity nor the quantum theory lead us necessarily beyond the Kantian position, however far they may lead us beyond the physics upon which Kant based his statements.

The clearest statement of a view of this sort is that given by Bridgman in *The Logic of Modern Physics*. He definitely limits the meaning of any of our concepts, including time, so that valuable and exact significance can be given them only in terms of certain operations which we perform, and the concept indicates the observations made on the basis of those operations. These operations may be either physical or mental, and in the case of most concepts both will be included. Time seems to be defined in terms of operations of measurement which are predominantly physical. A strict following of this theory does not give us merely two concepts of time—one based on objective measurments and one on the operation of immediate (and perhaps casual) experience. It gives us as many different concepts of time as there are essentially different ways of measuring it. The difficulty of conceiving this is due to one's natural tendency to give some meaning to that which is measured, besides a statement of the operations involved in measurement. In other words, time is really meaningless unless we define whether local or distant measures are involved or at least what clock is taken as the standard. Bridgman's view differs from many in the thorough way in which it adopts the relativity position. Having named the clock that is standard for a definite problem and method of procedure, no absolute is needed. That is, he points out that if one sticks to a strictly operational view of concepts the only standard for measurement that is needed is the definition of the operations used in a particular measurement. This, of course, involves the idea that measurements that are performed by different methods can be compared only if there is some way of checking the operations involved. This is not always true for all ways of measuring which are called time; therefore, we may expect to have a set of time concepts rather than a single concept. One advantage of this is that it would avoid all the contradictions in connection with time which so many other writers (both ancient and modern) have noted. But whether it will not rob time of certain meanings that at least historically have been given it is a problem which Bridgman leaves unsolved. The implication is that many of the earlier statements about time are quite meaningless.

The view defended by Bridgman is like Cassirer's in abandoning any attempt to define time (and other concepts) in terms of properties. But while Cassirer defined time in terms of the unity of nature, ultimately the work of the mind, Bridgman defines it in terms of operations actually performed. He is quite clear in indicating that there are at present many gaps between our theories and the actual process of measurement, but does not rest, as some physicists do, with saying that our measurements are approximations, but points out that the gap can be bridged only by giving the actual specifications of the clock involved.

A view that is similar in certain respects, at least in recognizing the artificial nature of our concepts, is that by which F. A. Lindemann[44] attempts to solve certain contradictions involved in the quantum theory, particularly the implication of that theory as to the concept of time. It has already been indicated that time has always manifested certain atomic characters, but not in such a fashion as to contradict the sort of continuity demanded by physical measurements. It is the opinion of many that the quantum theory extends this view to the physical concept so that time becomes at once and in the same sense both continuous and discontinuous. Various solutions are proposed. Lindemann suggests that the contradiction arises because of the error, really an artificiality, of considering space and time (or even the space-time of relativity) as fundamental concepts. Because we attempt to describe reality in terms of mass, length, and time, there appear to be contradictions; these would disappear if we took mass, charge, and action as fundamental. This appears to be merely the substitution of one convention for another. He points out that there is a particular difficulty in considering time to be discontinuous, because it is a purely conventional concept and by definition is continuous. There is no similar difficulty involved in discontinuities in mass, charge, or action. While this last is unfamiliar as a fundamental concept, its use will eliminate difficulties of the quantum theory. It therefore has a definite advantage over time and may be considered "natural" whereas time remains purely conventional. This view seems to distinguish between two types of concept, the one purely conventional and the other having some relation to the external world such that it may be called natural. Time is of the former sort.

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[44] *Symposium on the Quantum Theory* (Arist. Soc. Suppl. Vol. IV).

This completes the survey of the considerations concerning time which are being proposed by those writers who are predominantly interested in the results of physical investigations. There are others to whom reference might be made, but these suffice to place the main considerations before us.

The work of the next writers to be discussed takes into consideration not only the physical theories but also in a more specific way the theory of evolution. This theory is taken by them to mean the emergence of real novelty. Moreover, their whole approach is philosophical rather than purely scientific; that is, they are primarily interested in the fundamental ideas involved and not in specific scientific theories. The first two to be considered are Bergson and Carr, whose views are similar in many respects.

There are two factors which are necessary for an account of our ideas concerning time according to Bergson. There is the evolutionary process everywhere present. This is something more than emergent evolution as the term is employed by Lloyd Morgan and Alexander, who mean that given certain factors which may occur in relations of varying complexity, a new quality emerges with a certain degree of complexity of relationship. The appearance of real novelty is even more fundamental in the case of Bergson. This novelty plays an important part in forming our ideas of time. The other factor is *la durée immédiatement perçue*, which constitutes the continuity of our conscious life. In *Durée et simultanéité* (p. 54), he discusses the nature of the continuity of time. It is a passage which does not take place by separable steps, movement which cannot be broken up into stages without destroying its temporal character. *Durée* is also likened to memory, but a memory which contains change within itself. A melody is a good analogy and one which Bergson uses to bring out the nature of time. If one can become entirely absorbed in the fluidity of a melody, and then analyze this experience, one has a good representation of the nature of our life which ultimately reveals the nature of time. A melody, however, with its definite sounds in succession is not a perfect representation, for there is too definite a quality to each successive step. *Durée* is thus to be thought of as pure continuity, and is neither measurable nor divisible without destroying its characteristic quality. It is interesting to note that with all his insistence on continuity Bergson also suggests that some discreteness or atomicity is applicable to time. A melody involves, in its very nature as a melody, a certain wholeness; both a completeness of the melody as a whole and also a certain completeness of parts of it, and the novelty which is possible in a melody is dependent on there having already been attained a certain unity upon which this novelty is grafted as something new. Thus, if our awareness of duration is a factor in our perception of time and enters into our concept of it, and if this perception can rightly be compared to a melody, then time is not a blank continuity but certain parts have a real unity, that is, there is a certain type of discreteness as well as continuity.

Bergson is quite clear in the distinction which he draws between this immediately perceived time and the time which the physicist employs. The separation is even more complete for him than for the writers already quoted, and he maintains it more consistently.[45] The emphasis for Bergson is always on the importance of the immediate experience as furnishing the basis for a philosophical concept rather than on any scientific analysis of experience which because of the abstractness of science is always incomplete and, in his view, false.

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[45] H. Bergson, *Durée et simultanéité*, p. 234.

H. Wildon Carr, with an emphasis on the importance of activity as a fundamental concept which is very similar to Bergson, takes the contributions of science much more seriously. Concerning activity, he pointed out that it implies a type of change which is more than mere succession; rather it involves becoming, the becoming actual of what was potential. This is reminiscent of Aristotle. This sort of change manifests a type of continuity since the later stages grow out of the earlier.[46] This idea of activity is connected with the awareness of time, and would seem to be like many other discussions. But, in writing of time itself, he made statements which are difficult to reconcile with each other. For example, in *The Principle of Relativity* he said that time is a concept but, on the other hand, is not an abstraction. It is not concrete as objects and events are, but it is not abstract. It is one of the two frameworks of the physical universe, which contribute continuity to it. Concepts which are not abstract are almost, if not entirely, impossible to think about without falling into an abstraction. The test for such concepts which Carr proposed is consistency. Now this may mean that the concepts of space and time, being artificially constructed forms, are not abstract in the sense that concepts of sense qualities are, or any other abstractions from our immediate experience. Undoubtedly Carr's concept of monadic activity, and the importance of monads for his system, lent to this view a different slant from that of writers who would not accept his view that ultimate reality consists in forms of spiritual activity, or monads. Carr took into account both the theory of relativity and the quantum theory in formulating his metaphysics.[47] In a symposium already referred to he attempted to solve the difficulties which it brings out in our usual idea of continuous time, by analyzing the concept of continuity. He begins by stating that of two concepts, one of a scientific object, which by definition is subject in all respects to mathematical laws, and one of an object given in sense experience, the latter must be taken as more fundamental. Following out this, he suggests that there are three concepts of continuity which are commonly employed without recognizing the difference between them. The first is psychological, that is, the continuity of which we are immediately aware in our own experience of becoming. The second is mathematical, which is an arbitrary concept defined as involving both discreteness and compactness. For example, time in mathematical terms is continuous because made up of instants which are quite distinct from each other (discreteness), and between any two of which another can be found (compactness). The third type is physical continuity, which pertains to objects in space and time. This is often treated as mathematical continuity, but the difficulties of the quantum theory indicate that this is incorrect. Physical continuity is different from mathematical and probably more like psychological. This is a necessary result of the discovery that the fundamental nature of reality is active. In so far as physical nature involves becoming and must be conceived as a process, the more or less artificial continuity of mathematics, while it may remain very useful for some purposes, is inadequate for any complete explanation. According to Carr, this means that time is more important than is space. Mathematical continuity is a concept applicable only to static conditions and to our inadequate attempts to represent activity in other than psychological terms. The continuity of becoming, and therefore of time, is a more concrete and important description of reality.

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[46] *A Theory of Monads*, esp. p. 146.

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[47] H. W. Carr, *Symposium on the Quantum Theory* (Arist. Soc. Suppl. Vol. IV), pp. 48–49.

Although this subjective attitude toward time is widespread at present, it is not universal. Three writers who represent the objective attitude have been chosen because they present sufficiently different attitudes to be dealt with separately and together they present the chief positions. Alexander has given perhaps the most thoroughgoing realistic metaphysical scheme so far developed in the twentieth century. Time plays so important a part in his system that it is impossible to deal with it in complete detail within the confines of this essay. Although it was developed independently of the theory of relativity, his view of space and time is in accord with it. Space-time is presented as fundamental, so that space and time are interdependent. Time has two empirical characters—succession and continuity. These seem to be contradictory attributes, but are not really so. The contradiction is solved by the mutual relation of dependence of space and time; neither one can exist alone. This double aspect of experience is all pervasive; it is the fundamental type of which the mind-body relation is a late development, one which is a useful example but should not be taken to be as fundamental as the space-time relation. This indicates something of Alexander's divergence from any of the subjective views such as Bergson's.

His treatment of time is also quite different from that of the physicists. Time is not a concept, or an abstraction, or a term indicating an operation of measurement. It is rather one of the two fundamental empirical existences; true time is not completely independent, but it is space-dependent rather than mind-dependent. If our concept of this existent is analyzed, the two characters which have so often been noted appear, i.e., atomicity and continuity. The central character of time in Alexander's system is developed in his assertions about the evolutionary nature of reality. Development, or the emergence of new qualities, is an essential feature in his system, and this emergence is definitely connected with the time factor in reality.

Whitehead is also among those who maintain that the theory of relativity lends no support to a subjective theory of time. It is concerned with the fact that measurements are relative to the observer's body and to its motion; but this is a very different thing from saying that they are relative to his mind. He also stresses the distinction and differences between space and time, along with his recognition of their close relationship.

Whitehead differs from orthodox relativists in stressing the distinctions between space and time and in insisting that the space-time continuum must be homogeneous if we are to have any satisfactory theory of measurement as a basis for science.

In all his writings the importance of an objective temporal process is evident. The very concept of an event, which is a central note in his philosophy, makes this clear. If, then, time is to be taken as an essential metaphysical notion, it follows that we must reject the idea that there is any entity which can be fully understood in its essence without also understanding how it enters into time. Thus the "eternal objects," which are his substitute for Platonic ideas, cannot be understood except as they are actualized in a temporal process. Their actualization may take place either by inclusion or by exclusion; for example, the nature of blueness as excluded from the actuality of my handbag is as important as greenness, which is included in its actuality. Thus there is a universal relativity of all existences, actual or possible. This relativity includes the relativity of Einstein's theory as one manifestation. Relativity and temporality seem inherently bound to each other. Universal relativity may be only a first step toward temporality, but it reveals the fact that time is either a general principle of all existence or a pure illusion. On the basis of immediate experience Whitehead maintains that it is not pure illusion, for our experience is essentially of something going on. Since time must be accepted as in some way applicable, it must be a general principle. It is, however, not the only general principle. Immediate experience also reveals some permanence, and this may be the more significant principle. Time seems always to have certain trivial characters.[48]

In his earlier books[49] Whitehead discussed the problem of measurement in some detail. His suggestions toward a theory of measurement rest on the idea of extensive abstraction, on his discussion of congruence, and, as far as time is particularly concerned, on the assertion which he makes of an immediately perceived simultaneity. Any precision must rest on presentational immediacy. This involves the danger of ending in solipsism (which is, perhaps, inherent in the physical theory of relativity), which Whitehead avoids by his assertion of the essential relatedness of all nature.

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[48] For a discussion of permanence see *Adventures of Ideas*, chap. xx, and *Process and Reality*, Part V.

[49] *The Concept of Nature*, *The Principles of Natural Knowledge*, *Science and the Modern World*.

Whitehead's view, like that to be discussed next, is essentially an attempt to recognize the paradoxical nature of reality; the principles of flux and permanence, time and eternity, novelty and order, triviality and greatness, freedom and necessity, are given a place in his system. Nothing is left out for the sake of simplicity or even consistency; there is no absolute for whom temporal process is transcended in an eternal whole—neither does the eternal disappear in a Bergsonian flux.

Another writer who makes nearly co-ordinate the principles of time and permanence is Boodin. In his various publications the concept of time remains essentially the same. It is approached from the point of view of his characteristic pragmatic realism. In *A Realistic Universe*[50] he begins by indicating the contradictions involved in a timeless or eternal world. But he notes that this need not lead us to the Bergsonian emphasis on pure temporality or flux. The two immediately intuited aspects of experience, change and permanence, must both be given a place in any metaphysics; neither can be reduced to illusion. If it is granted that any description of reality involves the concept of time, the next step is a definition of this concept. Boodin, like Bergson, finds that many of our difficulties arise from a mistaken attempt to treat time serially. This only gives us the genus to which time belongs, and on analysis we discover no differentia by which it may be distinguished from other kinds of series. Further, a purely serial treatment of time cannot reveal its irreversible character. Therefore, the approach should be not the question "What sort of a series is time?" but "What differences do we note in our judging experiences which are due to time?" An answer to this question shows that time is that character which makes it possible and necessary to predicate contradictories of the same aspect of the world at the same point. This means that time is real in the sense of belonging to both the subjective and the objective aspects of the world. His definition of time as the principle of negativity or non-being is admittedly abstract, but an abstraction from our concrete experience of selfhood, and its abstractness is not a fault provided it is recognized as such. Indeed, no escape from the immediate moment of experience is possible without resorting to abstractions. Boodin points out that any definition of time involves circularity. Time is the condition of change. If it is defined as the principle of negativity, it is possible to see that motion and also the serial aspect of experience depend upon time.

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[50] See esp. Introduction to second edition and Part IV.

Boodin also approaches the problem of measurement. He finds that any absolute measurement of time is inherently impossible; measurement must be in terms of successive units, such as hours, or minutes, or light-years, and another series of measurements must be introduced to show that these successive units are equal. Since the units are successive rather than simultaneous, this is impossible without resort to time units themselves.

While Boodin's denial that the serial character of time is one of its fundamental qualities is like Bergson's, they differ in many respects, perhaps most significantly in that Boodin thinks that cumulation is not a universal principle of the temporal process. As time unrolls, much of the past is retained in the present, but not all. In this respect his view seems more like our immediate experience than does the view of Bergson. Much of the past is retained, values once achieved give us the sense of their eternality; but if time is to be taken seriously, achieved values are not assured to us as eternal, much may also be lost. Boodin is insistent in pointing out the advantages of a temporal view of reality. Only on such a view do we truly escape subservience to the past. That is, real novelty, something more than the cumulation of the snowball, is necessary if we are to assert any complete freedom. As scientific evidence Boodin refers to Heisenberg's uncertainty principle. He does not claim that this proves indeterminism, but at least it frees us from a determinism based on a characteristic of physical nature.

In opposition to this rather general tendency either to consider that the universe manifests primarily a temporal principle, or at least to consider two principles, one temporal and one eternal, to be co-ordinate, the earlier view that eternity is prior persists. Usually no new considerations are cited. However, the work of F. S. C. Northrup is novel enough to demand separate treatment. In *Science and First Principles* he works out in detail a physical theory of the universe which takes into account the major problems that have been mentioned concerning time. Such a philosophy he defines as one resting on two principles, that the real is physical and is being, which is to say that it does not changes its properties. Two other types of theory have developed to deal with problems arising from special forms of a physical theory. These are the mathematical and functional point of view, the former represented by Plato and Eddington (to cite an ancient and a modern example) and the latter by Aristotle and Whitehead. The principles underlying a mathematical philosophy are that the real is being and is rational, while a functional theory rests on the principle that the real is becoming. It is unnecessary to discuss in detail his criticism of these theories. The important point is that he maintains that the physical theory is the only one that applies to all our observations and that therefore difficulties involved in any special physical theory must be met by changes in detail rather than by a desertion of physical theories entirely.

Thus he offers his view of reality composed of microscopic atoms and a macroscopic atom and their respective fields as a physical theory which can account for change, for measurement, and for order, in a fashion which the earlier physical theory of atoms and continuous space could not. It is important to note that with the adherence to a physical theory time becomes a principle secondary to eternity or permanence. The ultimates, microscopic atoms and the macroscopic atom, do not change their properties, although the microscopic atoms move in relation to the macroscopic atom. Motion is derived from a property of microscopic atoms, but is ordered by their being compressed by the macroscopic atom. Thus while permanence and eternity are the fundamental principles, Northrup's view finds a place for time and change so that they at least do not appear to be illusions as in the Platonic or Hegelian views. His discussion of motion and measurement of space and time intervals also is consistent with the theory of relativity, which he points out was originally a physical theory although it has received both mathematical and functional interpretations. Another advantage of his view is the extent to which it unifies the principles underlying the various sciences. It was originally proposed as a basis for biological sciences which must deal with the unitary character of organisms and with their interaction with the environment. But it is equally applicable to physical and psychological sciences.

It is difficult to find in Northrup's writings any definition of time. But in the many references it is clear that it is thought of as being a concept derived from observations of motion, and involving certain measurable properties dependent on the macroscopic atom, which itself is eternal. The concept of time is therefore not fundamental but one of limited application, and derived from the motion of microscopic atoms.

This completes the strictly historical survey. It seems clear that the fundamental problems concerning time show surprisingly little change. They are now, as they were with the Greeks, its relation to motion or change, its measurable character, its relation to value, its relation to eternity or permanence, its dependence on human experience. The discussions of the various ages differ from each other because of special interests and new developments in special sciences.

The intention has been to present the material as objectively as possible, with a minimum of criticism except such as refers to comprehensiveness or consistency. Criticisms will vary more with the general philosophical position than anything else. Certain criticisms are implied in the final chapters, and the influence of the various points of view on the author is apparent particularly in the last chapter.

CHAPTER V

THE PROBLEM OF THE REALITY OF TIME

It has already been pointed out that the aim of this essay is Aristotelian rather than Platonic, in so far as the intention is to analyze and define what men mean by the term "time," rather than to analyze and define that which is taken to be a metaphysical entity. It differs from Aristotle's treatment of the subject chiefly because it must take into consideration a more developed scientific attitude and results than that with which he had to deal. On the basis of that similarity it would appear that the first problem is one which has been neglected so far to a considerable extent; that is the question, "Is time real?" Perhaps a better way of expressing this problem is: How can one determine the meaning of reality as applied to time? Newton and Clarke, for example, held that time is an objective existent, having the same type of reality as a table or chair. This is a rather rare point of view, although to some extent it was tacitly adopted by physics along with the Newtonian definition. It is not held generally by scientists at present. Time has also been considered to be a quality or characteristic of objective existents—an attribute analogous perhaps to extension. Finally, in the most general use time has been said to be real in the sense that its passage makes a difference. In fact, the problem of the reality of time may be only another way of raising the problem of change. The two problems are not synonymous and yet cannot be separated entirely. In the historical sketch comparatively few references to the arguments against the reality of time have been included. This may be justified by pointing out that, if there is one thing which modern science leads us to take seriously, it is this notion of the effect of the time passage. It is quite clear in the preceding chapter that the present tendency among philosophers is to recognize its full significance. However, before completing the survey it seems fitting to review briefly the typical arguments against the reality of time.

Starting from the proposition, "The real is the rational or conceivable," one may argue that time is unreal on the basis of its contradictory character. These arguments have been presented in many ways of which typical ones will be cited.

The first contradiction is one to which reference has already been made: that no part of time ever exists to which the term real may be given. This was pointed out in connection with the discussions by Aristotle and by Augustine. It was also developed by J. S. Mill in his *Examination of Sir William Hamilton*. The nature of time is such that when the present is, the past has been and *is no* longer, the future will be, but *is not* yet, while the present which *is*, turns out on analysis to be not a part of time but only the boundary between past and future. This confusion rests in part on the construction of language. But it is a more serious difficulty than merely language and leads to one of two conclusions. Either time is an ideal construction (the general Kantian view) or a concept of time as purely continuous is inadequate to enable us to deal with real change.

The second paradox I shall quote from F. H. Bradley:

> If you take time as a relation between units without duration, then the whole time has no duration, and is not time at all. But if you give duration to the whole time, then at once the units themselves are found to pos-

> sess it, and they thus cease to be units. Time in fact is "before" and "after" in one; and without this diversity it is not time. But these differences cannot be asserted of unity; and on the other hand and failing that, time is helplessly dissolved. Hence they are asserted under a relation. "Before in relation to after" is the character of time; and here the old difficulties about relations and quality recommence.[1]

Thus, if we start with a definition of time as involving duration, we are forced to the conclusion that it is "mere appearance." Bradley's argument certainly seems to challenge one of the two possible conclusions suggested from our first paradox, namely, that time is atomic.

An argument which is similar in some respects, but which he claimed had a different basis, was offered by McTaggart. His argument depends on an analysis of time into two series. The A series is that of past, present, and future, and this, McTaggart held, was essential to the nature of time. The B series is that of earlier and later; this is not ultimate but rests on the C series, which is serial order. The C series is, however, not an adequate basis in itself for the reality of time.

Changes in the A series are necessary for any temporal event. This turns out, on analysis, to be change in quality or in relation. Thus the event is not the same event since its qualities are different; or at least it is not completely the same if its relations are different. Thus the A series cannot be real, and this rejection involves the rejection of the B series. The C series, however, may be real—but in itself this is not an adequate basis for time. The only solution seems to be to take the A series as ultimate, and any metaphysics must take something as ultimate. But to consider that the A series cannot be analyzed makes it meaningless, in McTaggart's opinion. For every event must be past, present, and future. But these are contradictory terms. We escape the contradiction only by using different tenses of the verb, i.e., "was past" and "will be future." Thus we are involved in a vicious circle, for the tenses which are used to explain time also imply it.[2]

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[1] *Appearance and Reality* (1930), p. 39. Reprinted by permission of the Clarendon Press.

These two difficulties are, in part at least, difficulties in our thinking about time. They may be due either to the thinking or to time, although on any of the subjective views of time they involve both. There remains, however, a difficulty which seems more definitely due to

[2] "The Unreality of Time," *Mind*, XVII (N.S., 1908), 457 ff.

the nature of time. It might be summarized thus: Any physical process takes place in time (as well as space) and therefore can be divided into various subprocesses occurring in a definite order. But each of these subprocesses also consists in definite stages in order, and so on. Thus no part of the process can be completed until all the earlier stages in it have been completed, and since there is no indivisible first stage, the process as a whole cannot be completed, for all the stages can never be successively passed through. This is the more usual form of stating the difficulty, and it is ordinarily solved (?) by pointing out that since time is infinitely divisible the infinite number of "instants" can be successively passed through in a finite period of time. They would have to be durationless instants of course.

The difficulty with which Professor Whitehead is concerned is the obverse of this. Not only can the process not be completed, but it can never begin; for no process, or subprocess, can occur until a part of itself has occurred, and since that part is also divisible into ordered parts which must occur in sequence, there can be no actual beginning.

Neither of these difficulties is necessarily fatal. Processes certainly do occur and must be explained as "appearances," or else some theory of time must be offered which makes change possible. The view that time involves units or epochs of real significance may be a clue to such a solution.

However, this paradox of temporal process need not be taken so seriously. Professor Blake offers a criticism of the solutions proposed by James and Whitehead and also of their assertion that the traditional solutions are inadequate. Neither the unreality of time, nor its atomicity, follows from these paradoxes. The simple fact is that processes do occur and have the character of involving successive stages in a definite order.[3]

The next difficulties are those that occur in connection with measurement. These are entirely different from the paradoxes just discussed. It is held by many that we have a direct intuition of simultaneity, or of the equality of two durations, and base both an argument for the reality of time and a theory of measurement on immediately perceived simultaneity or equality. Otherwise time measurement involves a set of rather particular rules which we assume not because they are true (whatever that may mean) but because they are convenient. These rules are never exact, and by use they are progressively improved but without reference to that to which they are approximations. The view is best stated by Poincaré, from whom I quote.

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[3] "The Paradox of Temporal Process," *Journal of Philosophy*, XXVII, 646.

> To conclude: We have not a direct intuition of simultaneity, nor of the equality of two durations. If we think we have this intuition, this is an illusion. We replace it by the aid of certain rules which we apply almost always without taking count of them.
>
> By what is the nature of these rules? No general rule, no rigorous rule; a multitude of little rules—applicable to each particular case.
>
> These rules are not imposed upon us and we might amuse ourselves in inventing others; but they could not be cast aside without greatly complicating the enumeration of the laws of physics, mechanics and astronomy.
>
> We therefore choose rules, not because they are true, but because they are the most convenient, and we may recapitulate them as follows: "The simultaneity of two events, or the order of their succession, the equality of two durations, are to be so defined that the enunciation of the natural laws may be as simple as possible. In other words, all these rules, all these definitions, are only the first of an unconscious opportunism."[4]

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[4] "The Value of Science"; *The Foundations of Science* (1921), p. 234. Reprinted by permission of the Science Press, publishers.

This is clearly a statement of the operational view of concepts and amounts to saying that there is no meaning to the question, "Is time real?"

Closely connected with the arguments concerning measurement are the psychological arguments. These may be grouped under two heads. The first have to do with normal or usual experiences; the second, with abnormal or unusual experiences. These arguments are based on the view that the real is the objective.

It is claimed that our normal experience of time is traceable to three elementary experiences: apprehension of an event as having *duration;* apprehension that an event has occurred *before*, or that one event has occurred before another, which leads to the construction of ideas of past and of future; apprehension of two events or objects as *simultaneous*. From these we gradually construct a time concept, first for our own life-history and then pass to a universal time scheme. The time experience of individuals is not uniform; but we construct the idea of a common and uniform time from our ability to co-operate and to perceive rather regular changes in objects, such as the movements of the planets. According to this view, the moment of time is a state of mind peculiar to the one experiencing. This is the view which appeared in a good many of the psychological discussions referred to in the historical section. It does not involve the denial of the reality or objectivity of change but only that of time. Time is a character involving not only change but also the perception of duration, and as such is mental.

Time may also be said to be unreal on psychological grounds in the sense that it is not involved in all experience, and as it is supposed to be universal it should be a factor in all experience. This argument usually involves reference to abnormal or unusual experiences. The absence of a temporal factor is notable in the mystical experience in which since there is only one event, time is lacking since it would involve a comparison of events or awareness of change. The experience of time is also impossible in this case because in the very nature of the mystic's experience there is no division of attention and therefore no comparison is possible.

Another argument is that which starts from the premise that the mystical experience reveals reality in a way in which ordinary experience does not. This experience is said to be essentially timeless, or to reveal reality as timeless, and it is considered more important than usual experience, which manifests wide variations in temporal quality. In estimating this argument it should be noted that mystics always consider that experience as having greater significance than our usual experiences. In this connection I quote Baron von Hügel. "All states of trance, or indeed of rapt attention, notoriously appear to the experiencing soul in proportion to their concentration, as *timeless;* i.e., as non-successive, simultaneous, and hence as eternal."[5]

There is another argument which asserts that time is unreal because otherwise it would destroy all value. This is the Platonic position and it has been phrased variously. We are immediately conscious of the world of our experience as one involving value. If value is real, it cannot be subject to the vicissitudes attendant upon time; therefore time cannot be real. This type of argument always involves a contrast between two types of knowledge and their objects, such as contemplation of ideas as opposed to opinion concerning the sense world, the preference, of course, being given to the former. This view recurs constantly and constitutes the

[5] *Eternal Life*, p. 27.

most serious objection to considering that the time process is real. In Plato's statement that time is "the moving image of eternity," it is clear that time is an illusion, and that eternity is characteristic of the world of ideas and values. On quite the same basis as Plato, Dean Inge maintains the priority of the eternal:

> Faith can be satisfied with nothing short of Plotinus' confidence that "nothing that truly is can ever perish"; and this belief compels us to assert the existence of an eternal, unchangeable background, of which an unending temporal series would be at best only a symbol.[6]

This is the most important of the arguments, but it is not decisive. The relation of time and values is a much more complex affair than this argument would suggest. In a world as apparently imperfect as this, it is a question whether value can have any real significance in independence of the time process. Also it is not demonstrated that the eternity of one class of existents, as values, is incompatible with the temporality of another.

There is finally an argument from the deterministic or even the mechanistic view which denies the reality of time because determinism is incompatible with real novelty while the reality of time implies it.

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[6] *The Philosophy of Plotinus* (1918), II, 70. Reprinted by permission of Longmans, Green & Co.

These objections to considering time to be a real and important factor are all real objections, and remain largely unsolved. But in view of the insistent nature of time perception and its immediacy, they do not seem sufficient reasons for relegating to the realm of illusion all perception of time and change.

It might be pointed out that this matter of reality is in the last analysis a matter of more or less. Time, like every other part of experience, is real; the problem is rather, "Real in what sense or as applicable to what class of objects?" Under what categories can we describe best that aspect of our experience which we designate as time? The contradictory character may be due to using the same term for different aspects of experience, and if we saw that they are different aspects, we might no longer consider them to be contradictory. Even if all contradictions cannot be solved, this may not be due to any contradictory character in the idea of time but to our inability to limit its use properly.

CHAPTER VI

TOWARD AN ANALYSIS OF THE CONCEPT

It has become increasingly clear in the course of this study that one's approach to the problem of time is determined by one's philosophical position, while it is equally true that the difficulties involved in framing this concept may change radically either one's metaphysics or one's epistemology. The survey of the changing opinions, of the problems involved, and of the factors discussed suggests that a pragmatic treatment of the concept would clear up many of the difficulties. This discussion is included in this study because it serves to some extent to summarize the trends that can be observed, and because it seems to be a promising approach to the difficulties although the problems are not entirely solved.

Any concept is an abstraction from experience and certain of its factors, at any rate, can be traced to immediate awareness. The tests commonly applied are consistency and usefulness. These are not entirely independent tests, but are sufficiently distinct to be differentiated in our analysis. If the test of consistency is applied to the concept of time as it has been developed in the historical chapters, it appears that there are connected with this term various meanings between which there are persistent contradictions. Each of the conflicting views, however, meets the test of usefulness. Since these concepts are inconsistent, no purpose is served by treating them as if unified; in fact, much confusion has arisen through this attempt which persists in part because of the fact that we so commonly use a single term for these different ideas. On the other hand, since the various concepts have proved persistently useful in dealing with different aspects of our experience or in dealing with experience in different ways and with different purposes, none of the concepts or elements in them can be disregarded.

First, time, like other concepts, is an abstraction from experience. It is, however, of a comparatively low degree of abstraction; in certain of its uses it is as close to immediate experience as any concept which we can frame. In others it is more abstract in that it excludes many aspects of experience, and is dependent on highly technical operations for its definition. In any of its uses it is important as pervading that particular mode of abstraction and therefore deserves to be called real. In other words, it is real in the sense that temporality is a vital factor in experience, does as much work as any other factor which can be named. It has sometimes been said to be unreal because, like any other namable factor in experience, it is not all-pervasive—that is, for certain purposes it is not important—also several characters have been grouped under this common head. This leads to confusion and apparent contradiction if it is not borne in mind that these are several characters and not a single one, and may thus lead to the view that it is illusory. As an abstraction from experience, time has necessarily a mental quality; but that does not mean that it is subjective in any peculiar sense—that is, it is not subjective unless everything is considered to be so.

Since there are inconsistencies in the various uses of the term "time," it is best to consider that in place of a single concept there should be more than one. The questions next arise as to how many such concepts there are and how they should be ordered. Here the general operational view is useful. No meaning should be attributed which cannot be derived from some mental or physical operation involved in dealing with experience. On the other hand, meanings which derive from entirely different operations need not be consistent with each other in quite the same sense that a single concept must be self-consistent.

This serves immediately to set off what may be called the "physical concept" of time. This is a concept defined in terms of certain measurements, certain observed coincidences made usually with the use of a particular sort of measuring device—that is, some sort of clock. This is the view held by Bridgman, except that he maintains that this is the only sense in which the term "time" should be used and that other factors in the concept are meaningless. The only special theory of measurement needed is a definition of the operations actually involved in making the measurement. This, Bridgman maintains, is not difficult. It would appear that some difficulties might arise if the clock had to be constructed, but if a natural clock is assumed, and this always seems to be the starting-point, it needs merely to be pointed to and the operations described. In this sense of the term, the definition of time is contained in the definition of the operations. Since these operations are by definition measures, there can be no later question as to the measurable character of time. The main difficulty in our thinking about this use of the term is to avoid supposing that time is some entity other than the measures themselves. Whether or not time in this sense is continuous or atomic would depend entirely on the sort of measuring device used. Certainly the clocks ordinarily assumed are such as would make possible continuous measurements. The quantum theory may point to another sort of clock. There would then be no contradiction involved; the continuity or discreteness of time would be a way of referring to the sort of clock used.

But while no special theory of measurement is involved, the general nature of measurement as comparison must be taken into account. It also should be noted that any such definition implies that time is extended and that some definite structure is present in order to determine what is being compared. The character of extension supplies the necessary similarity which must exist between any two things that are to be compared; but unless there were some structural factor, there would not be sufficient definiteness to allow for measurement. This is furnished by the assumed clock. For example, the frequencies of all spectra given by any sort of atoms contain a constant factor; the atom then can be taken as a clock and this constant factor considered as a natural unit of time. It should be noted that the constant character of this unit is ultimately an assumption. The same would be true if any vibrating system were taken as a clock and a single wave-length assumed as a unit. Assuming it makes certain equations simpler than they would otherwise be; this is the justification for the assumption. The assumption was suggested, however, by measurements based on some other sort of clock, whose units in turn were based on assumptions. Ultimately one is forced back to some perceived similarity in immediate experience, which must be taken as the unit. Its use has led to changes in the unit used in order to deal as simply as possible with that aspect of experience. It should be noted that this theory of measurement is dependent on the general pragmatic view that usefulness constitutes truth. The definition of a clock and the assumption of equality for the unit is the equivalent of a definition of congruence.

There are two other aspects of measurement which should be dealt with here. First, the problem of measurement has been emphasized by the theory of relativity. As has been pointed out, this has led in some quarters to the assumption that the measurement of space and time, or space-time, is subjective in some special sense. This does not seem to follow. But of what significance is the theory of relativity as far as the measurement of time is concerned? This much is clear. In physical measurement there are two factors to be considered. One is the structure involved, which has just been discussed. This is the only factor which needs to be considered for the measurement of individual time or of local time. The other factor is the perspective of the observer, or better of the clock. This is not a mental but a physical matter. Thus, in any kind of measurement we find variations. In the first case, that of the estimation of individual experiences, the variations are due to differences in the experiencing organisms, either separate individuals or the same individual under different conditions. In the second case, that of measurement of the duration of objective events, there is the added difference due to varying perspective. Neither of these differences is to be looked on as an inaccuracy. They are simply different measurements which are proper for different organisms and different perspectives.

One thing further should be pointed out. If one considers the theory of relativity, one sees that estimates of time vary with the relative speed of the observers, thus leading to different time systems. The difference in these time systems is a result of the defined measuring operations, for those definitions should include all factors involved. Thus it furnishes no special problem for a theory of measurement.

Similarly, estimates of time vary with the relative speed (to put it figuratively) of the observers' minds; that is, filled time is estimated as shorter than unfilled time even when by certain more objective methods they are found to be equal. The reverse is, of course, true of time as remembered, so perhaps too much should not be made of that similarity; but at least it seems to show that there is no special need here for a bifurcation into psychical and physical on the basis of the theory of relativity. The problem always is: "What sort of clock is designated for a given measurement of time?"

While restricted to the field of our actual operations, nonetheless certain characters of physical time can be distinguished. The first, extensiveness, was mentioned in a discussion of Professor Whitehead's view. He considers it a necessary basis for measurement. Extensiveness is the quality of events by which one extends over or includes another. It appears in the fact that no matter what two events may be taken, a third can be found which extends over both. It also appears in the case of partial overlapping. This quality is a factor in both time and space and is perhaps the most immediate factor in each, but is not sufficient alone to give us the concept of either. It is the immediate basis of continuity, which by definition applies to physical time. Continuity can be explained as the reverse of extension. It is that quality of events which makes it possible always to find an event included in any given event. Like extension, it has both a spatial and a temporal form. As far as time is concerned, both extensiveness and continuity are matters of potentiality rather than actuality. It is only in the most abstract sense that one can say that there is an event including any two others. Considering merely the temporal aspect, an actual concrete event must have both a certain degree of unity and a certain degree of completeness. It is perfectly possible to imagine two events such that one cannot see unity in the duration which extends over them both. It is also perfectly possible, rather more easily perhaps, to conceive of an event which cannot be divided into smaller durations having any completeness. For that reason, both extension and continuity belong to the realm of potentiality or abstraction rather than to the realm of concrete events. But it is with exactly that realm that the measuring operations of the physicist are concerned, so that it is quite possible for these two characters to apply to his concept of time.

The measurable character, which is perhaps the most obvious, has already been discussed. In the discussion of that factor it was made clear that there is no essential difference between physical time and psychological time. The only difference is in the kind of clock used, and, as was indicated, the ultimate assumption was in terms of immediate experience, i.e., a psychological clock, while that assumption has progressively led to the use of other clocks.

The foregoing discussion might be summarized thus: Physical time is defined in terms of some operation involving measurements. As such it manifests the characters of extensiveness, continuity, and definite structure. The second of these may not apply to all such concepts of time but certainly does to those ordinarily assumed. The structural factor is in part supplied by the clock, but is also involved in the epochal character of concrete events—that is, certain events manifest a characteristic wholeness; for example, a vibrating system with its recurrent phases. Here there is a completeness of a wave-length which is not true of other lengths. While this epochal character is a quality of concrete events which are not the general concern of the physicist, some ultimate unit must be taken as supplying the structural factor necessary for measurement.

Closely associated with physical time is the term as used by the mathematician. This is a concept reached entirely by definition and involving no physical operations in that definition. Time in this sense is a dimension of the space-time manifold, continuous by definition, and of even higher degree of abstraction than the physicist's definition. Being purely conceptual, it must be distinguished from the physicist's, although the distinction is not always clear in actual use. There is this relation between the mathematician's time and physical time: Ordinarily the measurements which result from physical operations are such as can be represented mathematically and many of the equations of physics could be predicted on purely mathematical grounds.

A noteworthy difference is in reversibility. Mathematical time has no essential direction, whereas entropy indicates that physical time is essentially irreversible. In so far as the physicist's definition of time is employed in the biological sciences, its direction is determined by the evolutionary process. This operational view of these two concepts and the recognition that neither refers to any metaphysical entity beyond the operations defined should be a real help in dealing with the problems arising from either the theory of relativity or the quantum theory.

A third and very different concept of time is also evident. It is what Boodin calls the "Principle of Negativity" and which he identifies with the time process. The operation in the case is two judgments concerning the same aspect of experience at the same place, which judgments are contradictory. The time process is just the appearance of these two valid but contradictory judgments. It might very well be maintained that this is a much more fundamental and general operation than either of the two classes just mentioned, and that therefore this concept of time is more significant. There seems to be no particular reason to attribute to time in this sense all the characteristics which the physical concept exhibits. For example, if it is continuous and measurable, it can be so only by introducing some further operation. That we have this habit is because of our failure to distinguish between these different concepts. Continuity or discontinuity, and also measurability, in anything like the mathematical or physical sense, cannot be applied to this fact of immediate experience, that we actually do make contradictory judgments about the same aspect of experience. Some further operation should be introduced into the definition to indicate the irreversible nature of the time process —that is, that there is a meaning to the order of these judgments.

These three seem to be the simple concepts—that is, each derives from one operation or type of operation. But, in addition, other operations have been performed on the basis of these, resulting in further judgments about time. The two contradictory judgments mentioned above may be compared, and this comparison reveals either that the second differs from the first in the sense of being more than the first or that the first has been lost and replaced by something lacking its characteristic value. From the first type of comparison has arisen the view that time is cumulative; from the second, the view that time can have no metaphysical significance in a world in which values are real. Certainly the possibility of this second type of change does jeopardize all values in so far as they are actual, and the denial of the time principle in favor of eternity would be a way of saving values. This view results, however, from an overemphasis on the second type of change mentioned, to the neglect of the first. The view that time is completely cumulative also is one-sided, but there is a sense in which this is closer to the facts. The present includes the past in a way in which it cannot include the future, and even values which cease to be actual mark the present in a way in which the absence of values never attained cannot do. This cumulative character of the time process appears most dramatically in judgments concerning living beings—either in judgments about the same individual as young and as mature or concerning various species which have evolved.

The contrast between time and eternity or timelessness was raised in connection with the time process and value. This contrast was important in much of the earlier thought as appeared in the historical chapters. It arises when we note that we make identical judgments concerning certain aspects of experience and also contradictory judgments concerning others; and, further, that these judgments can never be separated. It has been clear, at least since Aristotle, that if there were no change we should be aware of no passage of time. But neither should we if there were no permanence or recurrences. This experience of the two conjoined types of judgments gives rise to the concepts of time and eternity, neither of which is prior, because they cannot be separated.[1]

Undoubtedly, the contrast of time and eternity involves the idea of relatedness. This idea itself is one step, at any rate, toward a concept of time which is at once more complex and more general than those already discussed.

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[1] It should be noted that this factor of identical judgments, or of permanence and recurrence, is closely related to the factor of structure discussed in connection with the physical concept of time.

This is the use of the concept in the sense of creative advance. This is a synthesis of three (or four) ideas already discussed: relatedness, permanence, principle of negativity in both its aspect of cumulation and its aspect of loss. The initial operation is an appeal to immediate awareness. But for any complete definition a synthesis of the foregoing ideas must be performed.

The concept of creative advance is constantly useful, but most obviously in the understanding of the development of life, both organic evolution and the developing individual. It is also fundamental in any interpretation of consciousness. This creative advance proceeds in an ordered ceaseless succession. Its epochal nature is most apparent—that is, there are significant attainments which mark off real epochs. The nature of the epoch varies for different individuals. In connection with our own experience it is most obvious in the fact that experience comes in drops: that there is in a sense a unit of experience which is called the "specious present." This seems to furnish the basis for the experience of time and also for any comparison of time; that is, it is the basis for immediate measurement, and thus suggests a connection between this concept and the physical concept of time. It is quite clear, however, that this is a connection due to the unitary character of experience from which any abstractions are made, and is not the appearance of an identical concept. The specious present has definite limits, but also there is an overlapping of presents.

In addition to the epochal character of human experience we have evidence of epochs in other sorts of development. The facts leading to the quantum theory would be a case in point, although they do not lead to the conclusion that physical time is discrete. Also there is a completeness in the duration which includes a vibration which does not apply to any less interval and a unity which does not apply to any greater. A similar character appears everywhere in the organic world. If we consider any organism, there is a certain duration within which it completes its life-history, a cycle which is at once a unit and a completion. Thus wherever we look, from the smallest to the largest, from the simplest to the most complex, we have evidence of definite epochs of achievement. The epoch is determined for each organism by the nature of change of that particular organism. Thus there comes about a pervasive overlapping of epochs because of the multiplicity of organisms and their interrelations. There is also overlapping of epochs since one organism may have more than one type of epoch. Again our experience furnishes the clearest example. We might say that the unit for man, on the basis suggested above, is his life-cycle. On the other hand, we have already suggested the specious present as the typical unit. Both these have a claim to be considered, and there does not seem to be any reason for choice between them. We use them both in estimates of time: the one in our general estimates of brief intervals, the other in estimates according to generations.

It is this overlapping of epochs which furnishes the basis for what might be called concrete continuity in distinction from the mathematical meaning of that term. Concrete continuity is the fact that because of the overlapping of epochs it often makes no difference whether we deal with a duration which is an epoch or not. Continuity in this sense is derived from the nature of the epoch, a rather complicated overlapping of epochs being the fact which is so designated.

The cumulative character of time is another factor which enters into the creative advance. Because of this cumulative character it follows that time is irreversible. While this is not true of time in the most abstract sense, it is obvious concerning time as process that it is simply nonsense to say that time is reversible. If we say that time repeats itself, returns again to the same point, the very fact that we use the word "again," or the prefix "re-" indicates that the occurrence is a second occurrence, is later than the first. Now what does this necessary and inescapable distinction between the first and later instance of the same event mean? That it is not the same event. That in some way the later includes the earlier event, not as present but as having been present. As far as the physical concept of time is concerned, this factor is largely omitted, perhaps because of the importance of recurrence for measurement. But in this more concrete and complex form irreversibility is important; there is a meaning in the series caterpillar, chrysalis, butterfly which there is not in any other order. This significance can be illustrated from as many different realms as can the other factors of time. It is certainly obvious in our own experience. We judge that the man in a sense includes the boy who he once was.

Memory is a case in point; it is in a sense a relation of inclusion between present and past. Anticipation, on the other hand, is a striving to include. Thus because of its cumulative character the creative advance is irreversible.

The relation of time and values is also important if time is used in this sense. As has already been pointed out, one of the serious objections to considering time to be completely real is that if real it apparently brings into jeopardy any value to which we may have attained or which has in any way become actualized. There is no escape from this. Yet, on the other hand, it is entirely on account of this same temporal quality of experience that ideals have their significance. Ideals or purposes play a very important part in our life: certainly on a pragmatic basis they should be assigned as high a degree of reality as external objects. Yet it is only as time is real and cumulative that this is possible. That is, any striving toward the future can have meaning only if the future is not only related to the present but when actualized will in some sense contain the present.

There is still another relation of time to values. In our estimates of value we incline to consider the later experience as more important than the earlier, a preference for the present over the past but also for the future over the present. These judgments are very much complicated by the fact that through memory the past or present often affects the future, but if that can be eliminated, the future is considered as the most significant. Or, to put it in another way, the latter part of a man's life has a significance not true of the earlier. If this preference is to be taken as more than a custom—that is, if it is a significant reflection on experience—it implies the reality of both change and time in the sense of creative advance since the later stages include the earlier.[2] Both the irreversibility and the reality of time depend on this.

In a way this is a view similar to that of McTaggart, whose view has already been discussed except that he held that time was not real. We are faced not with a series of varying degrees of adequacy in which perfection is at the far end of the future but all of which exist at once (in so far as that phrase has any meaning independent of time), but with a changing series in which each later stage may include all values attained in the earlier. They are, however, included in such a fashion that their value quality may be altered. Thus the pain of the past may be present now as pleasure. We are reminded of the *olim meminesse iuvabit* of our school days. On the other hand, pleasure may also lose its pleasurable quality. Thus the creative advance assures that this is a world in which values are possible, may become actual, but in which there is an element of risk. On the other hand, any non-temporal interpretation of the world seems to make values perfectly safe, only impossible; for obviously they are not now completely attained or actual. Therefore, they are not, unless there is more than the present.

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[2] The significance of this is fully discussed by Professor E. B. Talbot in "The Time Process and the Value of Human Life," *Philosophical Review*, XXIII, 634–47, and XXIV, 17–36.

The reverse aspect of cumulation has already been discussed as in the case in which there is loss evident between two contradictory judgments. But there is another relation between earlier and later judgment which is particularly significant concerning the creative advance. That is that the earlier judgment is always incomplete, requiring the later, its contradictory, for its completion. This is not to deny that for certain points of view we may consider the present as determined. This determinate character of the time process belongs to the same aspect as the epochal character. But as there was a certain type of continuity along with this epochal significance, so along with cumulation there is the opposing aspect of incompleteness or indetermination—an awaiting the future for completion. It is this aspect which lends a pathos to the death of a child which cannot pertain to the death of an adult. It also supplies the meaning to the phrase "the promise of youth." The snowball of experience which the creative advance rolls is never just this snowball now, for it already has rolled on and is more, and by very fact of the passage of time always contains more possibilities than have become determinate.

INDEX

Absolute, 119, 145, 149, 161 ff.; time, 1, 11, 14, 82 f., 88, 103, 112 f.

Abstraction, 13, 25, 39, 132, 152, 154, 182, 189, 191, 210 ff.

Aeorum, 9, 74

Alexander, 180, 185–87

Alternative time systems, 2, 54, 160

Arabic, 31 f., 34

Archytas, 20, 27 f.

Aristotelian, 32–35, 40, 47, 54–75, 91, 197

Aristotle, xi, 4, 7, 9, 19 f., 23, 25, 27 f., 31, 35, 55–72, 78–80, 121, 182, 193, 199

Atomicity of time, 7, 10, 15–18, 23, 39, 54, 71, 77, 82, 86, 93, 97, 129, 149, 181, 186, 214, 222, 225–27

Atomists, 20, 23, 26, 77

Augustine, 33 f., 45–55, 197

Bergson, 9, 33, 154, 179, 182, 186, 190, 192

Berkeley, 109–11

Biology, 3, 10, 15, 35–37, 57, 81, 122, 135 ff., 139 ff., 151 ff., 221

Blake, 203

Bohr, 194

Boodin, 189–92, 221

Bosanquet, 148

Bradley, 199 f.

Brett, 26

Bridgman, 175 ff., 213

Bruno, 83–86

Cantor, 69

Carr, 179, 183–85

Cassirer, 158 ff., 177

Chrysippus, 29

Clarke, 105 f., 197

Cleanthes, 29

Condillac, 132

Congruence, 8, 189. *See also* Measurement

Consistency, 211

Continuous, 7, 10, 15 ff., 20 ff., 37, 39, 54, 59–71, 77 f., 82, 86, 93, 97, 149, 180, 184 ff., 214, 218, 222

Contradiction, 8, 190, 198 ff., 209, 221 ff.

Copernicus, 83 f., 159

Creative advance, 5 f., 9 f., 225

Crescas, 31 f.

Cumulation, 153 ff., 192, 222, 227 ff.

Cusanus, 82 ff.

Damascius, 40

Darwin, 122 f.

Dedekind, 69

Descartes, 27, 33, 91–97

Democritus, 20

Determined versus indeterminate time, 29 f., 210–32

Discreteness. *See* Atomicity of time

Driesch, 154

Duration, 25, 30 ff., 87 ff., 95 ff., 108 f., 111 f., 126, 133, 154 f.; pure, experienced, 4 ff. *See also* Bergson

Durée réelle, 6, 9, 33

Eddington, 167–71, 193

Einstein, 7, 13, 157

Entropy, 156, 170, 221

Epicurus, 23, 25, 34

Epochal. *See* Atomicity of time

Eternity, 6, 9, 29, 33, 40, 55, 74 f., 82, 97–103, 120, 143 ff., 150, 189, 193, 207 f., 224

Event, 1 f., 105 f., 112, 145, 168, 187 ff., 218

Evolution, 3, 6, 118 f., 124, 147, 156, 179 ff., 186, 221

Extension: Descartes, 91–97; Eddington, 168; interval, 28 ff. Whitehead, 218 ff.

Fichte, 118 ff.

Functional, 36, 193 ff.

Galileo, 86

Gassendi, 25 f.

God, 4, 30, 47 f., 50, 88, 90, 94, 101, 110

Haldane, J. S., 36, 151–54

Haldane, R. B. H., 163 f., 167 ff.

Hallet, 100–103

Hebrew, 31–34

Hegel, 119 f., 144, 151

Heraclitus, 37

Herbart, 126 f., 132

Hippocrates, 20, 35 ff., 57, 77, 121

Hume, 111 f.

Hutton, 120

Iamblichus, 28, 40, 44

Immediate experience, 10, 13, 166, 168, 175, 181, 188, 191, 203, 215

Indeterminacy, 16, 130, 170 ff., 180, 189, 192 f., 208 f., 232

Irreversible, 11, 169, 190, 221, 228. *See also* Cumulation, Entropy, and Evolution

James, 69, 126–30

Jennings, 155

Johnstone, 154 f.

Kant, 112–16, 151, 159 f.

Kantian, 1, 70, 118, 144, 199

Kepler, 86

Leibniz, 1, 103–6, 112 f.

Leisegang, 40

Life, 40–44

Lindemann, 178 f.

Locke, 106–9

Lotze, 143 f.

Lucretius, 23

Mach, 132

Mackenzie, 139, 148

McTaggart, 31, 149 ff., 200 f., 230

Mathematical, 31, 36, 39, 155, 158, 184, 193, 195, 220 f.

Measurable time, 4, 8, 10, 29, 34, 39, 44, 58 ff., 98, 133, 219

Measurement, 10 ff., 22, 26, 30, 51–54, 77 ff., 84 f., 108, 136 ff., 164 ff., 172 ff., 191, 203, 213 ff., 222

Mechanistic, 36, 122, 155, 171, 208

Mill, 132, 199

Morgan, 156, 180

Motion, 2, 4, 7, 12 f., 16, 21 ff., 40 ff., 57, 61 ff., 76 ff., 83, 87, 94, 97, 99 ff., 107; absolute, 82–87

Münsterburg, 132

Newton, 1, 11, 27, 87–91, 96, 103 f., 108, 112 f., 120 f., 124, 157
Newtonian, 133, 136, 144, 159, 197 f.
Northrup, 31, 36, 193, 196
Now, 7, 56 ff.
Nys, 74 f.

Objective, 1, 35, 45, 62, 74, 79, 132, 144; and subjective, 5 f., 11, 14, 20, 34, 191. *See also* Subjective
Operational, 14, 129, 148, 175 ff., 205, 212 ff.
Organism, 3, 16 f., 132, 138, 140, 142, 152, 155, 226 f.

Past, present, future, 51 f., 130, 169, 172, 199
Pearson, 29
Peirce, 69 ff., 130 f.
Perception of time, 3, 17, 106 ff., 125 ff., 143. *See also* Subjective
Philo, 41
Philosophy of nature, 6, 145
Physics, xii, 1 ff., 10, 11 ff., 15, 81, 91, 115, 125, 129, 135 ff., 152, 157, 172–79, 181, 198 ff., 203
Physical concept of time, 213–20
Pike, 156
Plato, 4, 19 f., 27, 38 ff., 78 ff., 193
Platonic, 33, 37–55, 72 f., 145
Plotinian, 34
Plotinus, 31, 40–44, 142
Plutarch, 40
Poincaré, 204 ff.
Positivism, 138, 160, 166, 169
Proclus, 40
Psychology, 3, 10, 17, 44, 46, 52 f., 81, 125–43, 154, 161, 205. *See also* Subjective
Pythagorean, 20, 27 f., 79

Quantity, 63–71
Quantum, xii, 2, 15 ff., 157, 170 ff., 183

Reality and unreality, 5 ff., 19, 24, 30, 34 ff., 54, 56 ff., 80, 130, 143 f., 185, 197–209
Relational view of time, 103–6, 112 f.
Relative time, 1, 82 f.
Relativity, xii, 1, 7 f., 11 f., 14, 138, 140, 157, 163 ff., 183 ff., 187, 194, 217
Rest, 4, 24
Riemann, 163 f.
Royce, 144–49
Russell, 65, 68 f.

Schlick, 164–67
Scholastics, 74 f.
Schopenhauer, 115–18, 148
Simplicius, 27 f., 72
Simultaneous, 2, 172
Single time series, 7, 9
Space, 4, 11, 13, 31 f., 58, 104
Space time, 1, 11, 14, 185
Specious present, 127, 145, 227
Spencer, 123 f.
Spinoza, 33, 97–103, 120
Stoics, 29 ff., 35, 40
Strato, 72 f.
Sturt, 133–39, 148
Subjective, 25 f., 32 ff., 40–55, 61 ff., 79, 109–12, 134 ff., 142, 167 ff., 172–75, 185, 201, 212, 216

Unit of measurement, 8, 22
Usefulness, 211

Value, 151, 192, 207, 223, 229–32

Weyl, 171–74
Whitehead, 9, 21, 187 f., 193, 202, 218
Will, 115–17, 141, 147 ff.
Wolfson, 31 f.
Wunderle, 23
Wundt, 126 f.

Zeller, 27 f.
Zeno the Eleatic, 4, 7, 20 ff., 26, 69, 77 f., 90
Zeno the Stoic, 29

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